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FINAL REPORT

ADDITIONAL THERMAL FATIGUE DATA ON NICKEL- AND COBALT-BASE SUPERALLOYS

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16. Abstract

The fluidized bed technique has been used to measure the relative thermal-fatigue resistance of 21 superalloys: B1900, B1900 DID, IN-100, MAR-M 200, Udimet 700 wrought and cast, NX-188, WAZ-20, TAZ-8A, M22, IN 713C, IN 738, IN 162, MAR-M 509, René 80, RBH, NASA VI A, TD-NiCr, MAR-M 302, WI-52, and X-40. IN-100, MAR-M 200, NX-188, WAZ-20 and TAZ-8A were also tested in the directionally solidified form. B1900, B1900 DID, IN-100, MAR-M 200, Udimet 700, NX-188, WAZ-20, and TAZ-8A were tested with surface protection. Among the 36 variations of composition, solidification method, and surface protection the cycles to cracking differed by 2-3 orders of magnitude. Some alloys suffered serious weight losses and oxidation. Previous fluidized bed thermal fatigue data on some of these alloys are reported in NASA CR-72738. Thermal fatigue data, oxidation, and dimensional changes are presented in this report. Metallographic and hardness data are reported in NASA CR-121212. This investigation is part of a general study of thermal fatigue conducted by the NASA-Lewis Research Center.

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FOREWORD

This report describes the work performed under NASA Contract NAS3-14311 on the project entitled "Thermal Fatigue Testing of High-Temperature Alloys." The report covers the period June 11, 1970 to February 28, 1973. Other fluidized bed thermal fatigue data of nickel- and cobalt-base alloys obtained between March 24, 1967 and May 20, 1970 are reported in NASA CR-72738.

This report is presented in two parts. Part 1, presented here, describes the thermal fatigue testing and the results obtained. Part 2 (NASA CR-121212) describes the metallographic examination.

The NASA personnel assigned to this contract were:

Leonard W. Schopen - Contracting Officer
Peter T. Bizon - Project Manager

The IITRI personnel who contributed to this project include Maurice Howes (Project Manager), E. R. Porlier (Administrative Supervisor), R. K. Nolen, G. Grzeda, T. Croak, E. Chester, L. Hopkins, and V. Johnson.

Data are contained in Logbooks No. C20053, C20054, C20059, C200902, and C20061.

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SUMMARY

This investigation is part of a general study of thermal fatigue conducted by the NASA-Lewis Research Center. This program used the fluidized bed heating and cooling technique to measure the relative thermal fatigue resistance of 21 superalloys. An earlier investigation is reported in NASA CR-72738. The alloys in this investigation included B1900, B1900 DID, IN-100, MAR-M 200, Udimet 700 (cast and wrought), NX-188, WAZ-20, TAZ-8A, M22, IN-713C, IN-738, IN-162, MAR-M 509, René 80, RBH, NASA VI A, TD-NiCr, MAR-M 302, WI-52, and X-40. Four types of surface protection were used on selected alloys. These were Jocoat, Xcoat A, clad + Xcoat B and RT-1A coat. The IN-100, MAR-M 200, NX-188, WAZ-20, and TAZ-8A were tested in both the random and directionally solidified forms. The resistance to cracking was measured by cycling specimens between fluidized beds at 1129°C and 357°C, 1046°C and 274°C, and 1088°C and 316°C. The time of immersion in each bed was 3 minutes. The specimens were examined for cracks at intervals, and the lengths of the first three cracks were measured. When sufficient crack propagation data were obtained, the specimen was removed from test.

The tested alloys having the best resistance to thermal fatigue cracking were NX-188 directionally solidified and TAZ-8A clad + Xcoat B. The number of cycles required to crack different alloys varied widely, from over 6100 cycles for the best materials to 13 cycles for several of the worst materials. This represents a 500:1 difference in behavior under very severe testing conditions. Oxidation occurs during thermal cycling, and some alloys experienced considerable weight loss. The directionally solidified alloys were particularly susceptible and normally should be protected with a coating.

Metallographic examination indicates that as much attention should be given to processing the alloy as to the alloy composition. Directional solidification is an obvious case of improving properties through processing, but other techniques of controlling microstructure are also important. Any structure with a large constituent or line of constituents is potentially weak in thermal fatigue. The test results indicate that processing should be designed to give a fine well-dispersed structure without a pronounced dendritic pattern and without grain boundaries lined with carbides or blocks of other constituents.

INTRODUCTION

The purpose of the reported work was to use the fluidized bed technique to measure the relative thermal fatigue cracking resistance of twenty-one high-temperature superalloys that could be used for advanced air breathing engines. The study included metallographic and hardness studies before and after thermal fatigue testing. The work was carried out in a facility designed and built by IIT Research Institute.

This investigation is part of a general study of thermal fatigue being undertaken by the NASA-Lewis Research Center. Other parts of the study and the possible use of the data are described by Spera.[1] An earlier part of this general study was the previous fluidized bed thermal fatigue work by Howes.[2] An analytical life prediction to these data is given by Spera et al.[3]

Thermal fatigue is a possible failure mechanism in any situation that involves fluctuating temperatures. If certain materials are heated or cooled rapidly and continuously, cracking sometimes occurs. This phenomenon, which is often called thermal shock, is caused by thermal gradients present during rapid temperature change. As a result, strain is produced which is related to the coefficient of expansion of the material. Failure occurs when thermally induced stresses exceed the strength of the material after starting as a crack in the most sensitive area. In metals, the thermal fatigue mechanism often results in the gradual formation of a network of cracks and is commonly referred to as craze cracking, heat cracking, or fire cracking. Any part which undergoes temperature cycling during service is likely to fail by this mechanism.

Failures due to thermal fatigue can be found in brake drums, turbine blades, internal combustion engine pistons, rolls for forming hot steel, forging dies, railway wheels, furnace components, and in molds used for glass and metal molding. Thermal fatigue can become the dominant failure mode in aircraft gas turbine engines as the operating temperature and thermal gradients become more severe and the expected service life becomes longer.

Many methods of heating and cooling have been used to simulate the thermal cycles experienced in actual applications. Some of the earliest work used direct flame impingement on a surface. However, unless carefully controlled, the combustion products and variation in temperature conditions can introduce an arbitrary environment which can influence the cracking mechanism.

High-frequency heating and electrical resistance heating systems can be used to establish simulated thermal cycling conditions; however, they are generally expensive to construct for the

multi-station test facilities which are needed to amass data quickly. In the consideration of thermal fatigue, the crack propagation rate is as important as the start of cracking. For instance, a material that cracks early might be satisfactory if the crack propagation rate is very slow. With high frequency and resistance heating, the formation of a crack alters the flux or current density in such a way that the crack is overheated and measurement of propagation rate becomes meaningless.

The fluidized bed heating system for thermal fatigue testing has many advantages and no significant disadvantages. The bed construction is simple and relatively inexpensive. The rate of heat transfer to a specimen or group of specimens is high. The heat content of a particulate solid fluidized media is also high, so that a large number of specimens or a large specimen can be rapidly and repeatedly heated without lowering the bed temperature significantly. The fluid bed system uses low-velocity air flows (on the order of 1 fps), and in this respect the high-velocity gas flows in a turbine engine are not simulated. The first reported use of fluidized beds for thermal fatigue testing was in 1958 by Glenny and co-workers.[4] Since that time there have been many reports of the use of this technique to evaluate thermal fatigue resistance.[5-13] A bibliography of the literature of thermal fatigue up to 1967 was compiled by Carden.[14]

The original high-temperature bed described by Glenny was 6 in. in diameter and was heated by wire-wound elements of 4 kw total input. For this program much heavier loads of test specimens had to be cycled, and a bed diameter of 11.5 in. with a power input of 55 kw was required. The low-temperature bed was controlled at an intermediate temperature instead of room temperature; thus the lower temperature beds were required to have provisions for both heating and cooling. These features are described in the section under Experimental Work which deals with the thermal fatigue facility.

The entire report is presented in two parts. This is Part 1, which includes all thermal fatigue results, together with weight and dimensional changes. Part 2 describes the metallographic and hardness measurements.

EXPERIMENTAL WORK

Materials and Conditions

Thirty-six variations of alloys and treatment were studied in this program. These are listed in Table 1. Twenty-one different

material compositions were used as shown in Table 2. The variables studied in this program include

1. Composition

2. Test piece shape (i.e., double or single edge wedges)

3. Solidification method

4. Surface protection

5. Temperature of exposure.

For the thermal fatigue testing two types of test piece were used (Figure 1). Most testing used the double-edge wedge type having nominal edge radii of 0.025 in. and 0.040 in. Only four tests including the two clad tests were single-edge wedges (SEW) having a nominal edge radius of 0.030 in.

Five alloys were used in the directionally solidified condition. These were IN-100, MAR-M 200, NX-188, WAZ-20, and TAZ-8A. Randomly solidified specimens of the same alloy were also tested for comparison.

Four types of surface protection were used as follows:

1. Jocoat - a silicon-modified nickel aluminide coating (Pratt & Whitney Aircraft proprietary process PWA 47)

2. Xcoat A (used only on IN-100) - an experimental nickel aluminide coating applied by NASA-Lewis pack process. The pack composition was $1Al-1NaBr-98Al_2O_3$. The pack was under an argon blanket at 2000°F for 15 hr resulting in a coating about 2 mils thicks. After pack the specimens were heat treated for 25 hr at 2100°F.

3. Clad + Xcoat B - The 5 mil thick clad composition was 19.24Cr, 3.92Al, 1.22Si, 0.059C, bal. Ni. The diffusion bond process parameters were 15,000 psi for 3 hr at 2175°F. The diffusion bond process is completely described in ref. 15. Xcoat B was an experimental nickel aluminide coating applied by NASA-Lewis pack process similar to that above except that the pack composition was $1Al-1NH_4Cl-98Al_2O_3$ at a temperature of 1900°F.

4. RT-1A Coat - a chromium-aluminum duplex coating (Chromalloy Corporation proprietary process similar to PWA 32 but a lower temperature version).

Tensile properties at 1400°F (760°C) and stress-rupture properties at 1800°F (982°C) were obtained by NASA-Lewis using the uniaxial specimens (Figure 1). The results are given in Tables 3 and 4. The stress-rupture results for IN-713C, M22, TD-NiCr, B1900 DID, and IN 738 are significantly lower than average published data.

Thermal Fatigue Facility

A schematic drawing of the thermal fatigue testing facility is shown in Figure 2. It consists of a 9.0 in. diameter high-temperature bed situated between two 14 in. diameter intermediate-temperature beds.

The center high-temperature bed has either an Inconel retort or a silicon carbide retort (depending on the maximum temperature requirements), and a stainless steel air-diffuser box supplied with air from a low-pressure blower. The bed is heated by 12 silicon carbide elements with a total power of 55 kw. Heat insulation is provided by two layers of refractory insulating brick and 1 in. of Fiberfrax.

The intermediate beds are double-walled, with a stainless steel liner and a 1 in. insulation of Fiberfrax. Heating is provided by three Calrod elements (total power of 12 kw for each bed) situated above the stainless steel air box. For cooling, the heat exchanger can be either a multi-tube, water-cooled copper assembly (left bed, Figure 2) for bed temperatures up to 400°F or an air-cooled stainless steel jacket (right bed, Figure 2) for bed temperatures above 400°F. These heat exchangers are interchangeable. For all work carried out on this program, the air-cooled heat exchanger was used.

The specimens are cycled by means of automatically controlled pneumatic cylinders which are sequenced by timers and limit switches. The facility will cycle automatically for the number of cycles selected.

The air supply for fluidization is controlled through flowmeters for each bed. The maximum fluidization air demand is about 3500 cu ft/sq ft/hr (3500 cfh) for each of the intermediate beds at 100°F and 900 cu ft/sq ft/hr (600 cfh) for the high-temperature bed at 2000°F. Less inlet air is required as the bed temperature

is increased due to the expansion of the air as it passes through the bed. Tests show that the fluidization range is fairly narrow since the bed will rapidly empty if excessive air is used.

Each bed is fitted with four thermocouples for control, over-temperature protection, low-temperature test cutoff, and recording purposes.

Facility Performance

The high-temperature bed will operate at 2300°F (1260°C) using a silicon carbide retort and could be run at this temperature for testing small samples. However, as the weight of the specimen load in pounds per hour is increased, the maximum permissible bed temperature must be decreased. Otherwise the temperature of the heating elements would exceed the maximum permissible value of 2750°F (1510°C). With a specimen load of 15 lb, the maximum bed temperature is about 2000°F (1204°C) with a constant input of about 45 kw. At below 2000°F bed temperature, the Inconel retort may be used.

The intermediate beds will run at a maximum temperature of 800°F (427°C). When cooling a 15 lb load from 2000°F every 4 min, the air-cooled and water-cooled heat exchangers will hold the bed temperatures at 400°F (204°C) and 200°F (83°C), respectively.

Thermal Fatigue Fixture

The fixture used for this program is shown in Figure 3. It consisted of three RA 333 vertical supports of the same section as the test pieces and tapered at the bottom to simulate test piece configuration. Specimens were bolted between supports using threaded 330 alloy. The fixture could be adjusted for different numbers of specimens by inserting different spacer blocks at the top of the fixture. This fixture had an average life of approximately 250 cycles at the extreme test condition of 2065/675°F (1129/357°C).

Test Conditions

The complete range of test pieces was not available at the start of the program, and specimens were cycled as they became available for test. Sets of test pieces varied from twelve to six.

Specimens were placed at random in the fixture as regards position from end and orientation.

The following fluidizing conditions were maintained constant through the entire test series:

	Air Flow (Measured at 150°F, 2 psi pressure)	
	$ft^3/ft^2/hr$	$m^3/m^2/hr$
Hot bed	900	275
Intermediate bed	2100	640

The fluidized media was 28-48 mesh tabular alumina.

The time of immersion in each bed was held constant at 3 min. The temperatures used for each series were as follows:

Series	Hot Bed		Intermediate Bed	
	°F	°C	°F	°C
G	2065	1129	675	357
H	1915	1046	525	274
I	1990	1088	600	316

All test combinations were not tested at the three temperatures, and duplicate specimens were run under the same conditions in some cases. Table 5 summarizes the specimens tested at each temperature.

Measurement of Transient Temperatures

The transient temperatures achieved during the cycling of series G, H, and I were established using instrumented specimens, each fitted with five thermocouples. The couple positions are shown in Figure 4. Fourteen alloys were calibrated in this way: B1900, B1900 DID + Jocoat, IN-100, NX-188, WAZ-20, TAZ-8A DS, TAZ-8A (SEW), IN-713C, IN-738, IN-162, MAR-M 509, René 80, NASA VI A, and X-40. The thermocouples were magnesium oxide insulated, Inconel 600 sheathed, ISA type K (Chromel/Alumel) with an outside sheath diameter of 0.020 in. These couples were fabricated to meet specifications MIL-Q-9858 and ASTM E-235. The couples were run in grooves milled in the surface of the specimen. Grooves were 0.022 in. wide and 0.020 in. deep. The thermocouples were

secured in place using an air-setting two-part Allen P-1 ceramic cement. After curing at 600°F (316°C) an adherent bond is formed sufficient to hold the thermocouple in place. Temperatures were recorded on a multichannel high-speed recorder.

Complete tabulated data are shown in Tables 6 to 33.

Inspection of Specimens During Testing

The specimens were removed at regular cycle intervals, and the test edges were examined for cracks using a 30X microscope. Inspections were made at intervals such as 25, 50, 100, 200, 300, 500, 700, 1000, etc., cycles with the intervals lengthening with increasing numbers of cycles. At the longest exposures (up to 6000 cycles) intervals of up to 750 cycles were used. Inspection was complicated by the fact that not all specimens were available for test at the start of a particular test sequence and new specimens were added to the specimen group during the test. Thus not all specimens within the group had experienced the same number of cycles. When a crack was discovered, the length from crack tip to specimen edge was measured on both sides of the specimen and the average taken as the crack length. Measurement was made using a traveling microscope.

Table 34 summarizes the total cycles that each specimen underwent during test.

When sufficient crack data were obtained, the specimen was removed from the fixture and replaced by a stainless steel dummy specimen.

At regular intervals the specimens were weighed and measured, and hardness readings were taken. A Rockwell C hardness reading was taken on the surface at the center of the specimen and a 1 kg DPH taken on the end of the 0.040 in. radius after cleaning off the surface oxide with fine emery paper. These results are presented in Part 2.

RESULTS

Thermal Fatigue Data

Complete crack propagation data are contained in Tables 35, 36, and 37. Data are given as crack length versus number of cycles for a maximum of three cracks in each edge. The appearance of some

specimens after testing is shown in Figure 5. These specimens are from Series G, 2065/675°F (1129/357°C), which represents the most severe test condition.

The number of cycles requires to initiate cracks was of primary interest in this study. There are several ways of determining this number, which cannot be measured directly. Glenny[4] used the procedure of averaging the cycles between the last inspection cycle to show no crack and the first inspection when the crack was observed. A refinement of this method is to plot crack length versus cycle number and extrapolate to zero crack length. This latter procedure is of particular value when the test section is of constant thickness and the crack length versus cycle number curves approximate to straight lines. The wedge section specimen used in this investigation results in curved crack propagation curves and makes it difficult to accurately extrapolate the curves to zero crack length. The averaging method of Glenny has been used in this investigation, and the cycles to initiate the first crack in each alloy are summarized in Table 38.

In some cases the 0.040 in. test edge initiated cracks before the 0.025 in. edge. This was probably due to weaknesses in the 0.040 in. edge causing preferred initiation. Once a crack was well established, it is probable that the stresses were relieved sufficiently to delay crack initiation in the opposite edge. It was also noticeable that when several cracks propagated, they did so at regular intervals along the specimen. When one crack formed, it relieved the stresses locally and thus prevented another crack forming within the immediate neighborhood of the first crack.

Physical Changes During Testing

Weight changes during testing are given in Tables 39, 40, and 41. Dimensional changes are shown in Tables 42, 43, and 44. Specimens having the greatest weight loss are:

- IN-100 DS
- MAR-M 200 DS
- WAZ-20 DS + Jocoat
- IN-100 DS + Jocoat
- NX-188 DS
- NX-188
- TAZ-8A (SEW)

A complete summary of the average weight change rates for the complete testing cycle is shown in Table 45. This information should be used with some reserve since the weight change is sometimes nonlinear. Figure 6 shows the weight changes of some Series G specimens during cycling. Some specimens showed slight weight gains before losing weight.

Certain specimens, notably the B1900 and Udimet 700 alloys, showed dislocation in addition to dimensional change (see Figure 5b and 5h). This would indicate some instability in the alloy. Another interesting feature was the tendency of some alloys to crack at the fixing holes, usually starting at the hole and propagating outwards. These alloys included B1900, B1900 DID, IN-100, MAR-M 200, Udimet 700, IN-738, René 80, and RBH. It would seem that these alloys are more notch-sensitive than the remainder.

Ranking

If thermal fatigue cracking resistance is based upon the number of cycles required to form the first crack then the alloys can be ranked as follows for Series G, 2065/657°F (1129/357°C):

Rank	Alloy	Cycles to 1st Crack
Double-edge wedge specimens		
1 (highest)	NX-188 DS + RT-1A Coat	>6100
2	NX-188 DS	5125
3	IN-100 DS + Jocoat	1950
4	B1900 DID + Jocoat	1550
5	WAZ-20 DS + Jocoat	1350
6	B1900 + Jocoat	>1200
7-9	IN-100 DS, MAR-M 200 DS, TAZ-8A DS	1200
10	TAZ-8A	450
11	NX-188 + RT-1A Coat	200
12	X-40	150
13	MAR-M 509	100
Single-edge wedge specimens (SEW)		
1 (highest)	TAZ-8A (SEW) Clad + Xcoat B	6100*
2	TAZ-8A (SEW)	2350
3	Udimet 700 (SEW) Wrought, Clad + Xcoat B	1300

*Small cracks were present but obscured by peeling cladding.

All other specimens cracked within 100 cycles.

The most thermal resistant materials when tested at 2065°F (1129°C) are NX-188 DS and the TAZ-8A used for the SEW specimens. The materials in the top half of the ranking for double-edge wedge specimens are either directionally solidified or coated or both.

CONCLUSIONS

The purpose of this investigation was to use the fluidized bed heating and cooling technique to measure the relative thermal fatigue cracking resistance of 36 combinations of superalloy composition, specimen design, casting technique, and coating.

The alloys having the best resistance to thermal fatigue cracking are NX-188 directionally solidified and coated and TAZ-8A clad and coated. The number of cycles required to crack different alloys varied widely from over 6100 for the best materials to 13 cycles for several of the worst. This represents a 500:1 difference in behavior under very severe testing conditions.

Oxidation occurs during thermal cycling, and some alloys experience considerable weight loss. The directionally solidified alloys are particularly susceptible and normally should be protected with a coating.

The metallographic and hardness results are presented in Part 2 of this report.

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TABLE 1.- ALLOYS AND VARIATIONS USED IN TEST PROGRAM

B1900
B1900 + Jocoat
B1900 DID + Jocoat[a]
IN-100
IN-100 + Jocoat
IN-100 + Xcoat A
IN-100 DS
IN-100 DS + Jocoat
MAR-M 200
MAR-M 200 + Jocoat
MAR-M 200 DS
Udimet 700 wrought
Udimet 700 cast
Udimet 700 wrought, clad + Xcoat B (SEW)
NX-188[a]
NX-188 + RT-1A coat[a]
NX-188 DS[a]
NX-188 DS + RT-1A coat[a]
WAZ-20 + Jocoat
WAZ-20 DS + Jocoat
TAZ-8A
TAZ-8A (SEW)
TAZ-8A clad + Xcoat B (SEW)
TAZ-8A DS
M22
IN 713C
IN 738
IN 162
MAR-M 509
René 80[b]
RBH (experimental alloy)[c]
NASA VI A
TD-NiCr
MAR-M 302
WI-52
X-40

DS indicates that the alloy was directionally solidified. SEW indicates single edge wedge; all others double edge. DID (Ductility Improvement Discovery) indicates that the alloy had a small hafnium addition.

[a]Specimens supplied by Pratt & Whitney Aircraft Corporation.

[b]Specimens supplied by General Electric Corporation.

[c]Specimens supplied by Cabot Corporation.

TABLE 2. - COMPOSITIONS OF ALL ALLOYS USED IN THE PROGRAM

Alloy	Cast Number	Composition, Wt% C	Mn	Si	Cr	Ni	Co	Mo	W	Al	Ti	Zr	B	Other
B1900	54V6335	0.10	0.10	<0.10	8.11	Bal.	10.15	6.11	<0.10	6.09	0.98	0.08	0.013	4.28Ta, 0.16Fe, 4.28V
B1900 DID		0.09	0.003	0.06	8.13	Bal.	10.19	5.90	0.04	5.96	0.98	0.04	0.009	4.3Ta, 0.06Fe, 1.64Hf
IN-100 (also IN-100 DS)	KJ2206	0.17	<0.02	0.11	10.30	Bal.	15.10	2.96	--	5.45	4.76	0.084	0.016	0.21Fe, 0.97V
MAR-M 200 (also MAR-M 200 DS)	KD2012	0.15	<0.02	0.080	9.20	Bal.	10.25	--	12.55	5.05	2.13	0.048	0.017	0.36Fe, 0.96Cb, <0.01V
Udimet 700 (wrought)	6541	0.113	0.01	0.02	14.85	Bal.	17.50	5.10	--	4.55	3.45	<0.02	0.013	0.85Fe
Udimet 700 (cast)	85V2416	0.08	<0.10	<0.10	14.24	Bal.	14.87	4.18	--	4.25	3.26	<0.01	0.012	0.30Fe
NX-188	EXF1655	0.033	--	--	--	--	--	18.03	--	8.13	--	--	--	--
WAZ-20		0.17	--	--	--	Bal.	--	--	20.9	6.28	--	1.2	--	--
TAZ-8A	67-640	0.01	--	--	6.20	Bal.	--	3.86	3.86	5.96	--	0.88	--	8.01Ta, 2.44Cb
TAZ-8A[a]	T24	0.10	--	--	5.85	Bal.	--	5.41	3.90	6.40	--	0.52	39PPM	7.93Ta, 2.44Cb
M22	67-635	0.06	--	--	6.35	Bal.	--	1.96	11.37	6.24	--	0.65	--	2.87Ta
IN-713C	65611	0.11	<0.10	<0.10	13.40	Bal.	--	4.50	--	5.95	0.83	0.08	0.009	2.24Cb+Ta, 0.27Fe
IN-738	94V9529	0.17	0.01	0.11	15.98	Bal.	8.37	1.81	2.49	3.52	3.39	0.11	0.012	1.95Ta, 0.14Fe, 0.87Cb
IN-162	96317	0.10	0.01	0.04	10.03	Bal.	0.03	4.05	2.03	6.35	0.93	0.11	0.018	1.97Ta, 0.17Fe, 0.88Cb
MAR-M 509	T-3008	0.62	<0.1	<0.1	23.4	10.0	Bal.	--	6.95	--	0.19	0.54	<0.01	3.46Ta, <0.1Fe
René 80	101V9494	0.18	0.01	<0.10	14.0	Bal.	9.91	4.00	3.84	3.11	4.90	0.03	0.014	0.18Fe, <1PPM Ag
RBH	70-670-4	0.64	0.43	0.39	20.91	16.00	Bal.	--	5.46	0.33	0.24	0.16	--	3.20Ta, 0.73Fe, 0.05La
NASA VI A	FB5487	0.11	0.02	<0.10	5.86	Bal.	7.24	2.11	5.96	5.27	0.95	0.10	0.021	9.03Ta, 0.32Re, 0.39Hf 0.45Cb, 0.08Fe
TD-NiCr	1862 2858	0.038 0.020	-- --	-- --	21.39 19.72	Bal. Bal.	-- --	-- --	-- --	-- --	-- --	-- --	-- --	$2.5ThO_2$, .0005N, .006S $1.9ThO_2$, .004N, .007S
MAR-M 302	T272	0.88	<0.10	0.22	21.9	0.49	Bal.	<0.1	9.89	--	--	0.24	<0.01	8.80Ta, 1.11Fe
WI-52	59-682	0.46	0.21	0.28	20.86	0.23	Bal.	<0.05	11.06	--	--	--	--	1.75Fe, 1.87Cb
X-40	12C6412	0.48	<0.05	0.33	25.59	10.52	Bal.	0.04	7.87	--	--	0.03	0.005	0.46Fe, 0.02N

[a]This cast of TAZ-8A was used for the directionally solidified specimens and for the SEW specimens.

TABLE 3. - TENSILE PROPERTIES AT 1400°F (760°C)

Alloy	Proportional Limit psi	Proportional Limit N/cm^2	Proportional Limit % of Nominal 0.2% YS	Ultimate Tensile Strength psi	Ultimate Tensile Strength N/cm^2	Ultimate Tensile Strength % of Nominal UTS	Reduction of Area, %
B1900	136,000	93,800	116	158,000	109,000	114	8
B1900 DID	101,500	70,000	88	137,800	95,000	92	12.5
IN-100	115,000	79,300	92	140,000	96,500	90	13
IN-100 DS	122,000	84,100	--	150,000	103,400	107	16
MAR-M 200	124,000	85,500	102	145,000	100,000	107	5
Udimet 700 (wrought)	110,000	75,800	92	143,000	98,600	95	30
Udimet 700 (cast)	108,000	74,500	--	148,000	102,000	114	16
NX-188	104,800	72,300	85	130,900	90,300	101	3.7
NX-188 DS	126,600	87,300	77	134,500	92,700	79	3.8
WAZ-20	102,700	70,800	105	108,200	74,600	99	4.0
WAZ-20 DS	102,300	70,500	96	124,000	85,500	104	8.9
TAZ-8A	150,000	103,400	--	174,000	120,000	134	2
TAZ-8A DS	130,000	89,600	93	171,400	118,200	110	4.5
M22	139,000	95,800	124	153,000	105,500	116	8
IN-713C	118,000	81,400	109	147,000	101,400	108	12
IN-738	115,200	79,400	100	146,700	101,100	105	8.5
IN-162	130,000	89,600	106	163,000	112,400	112	11
MAR-M 509	42,600	29,400	80	90,000	62,100	105	13.5
René 80	110,100	75,900	110	155,600	107,300	101	10.8
NASA VI A	132,000	91,000	96	161,600	111,400	102	5.8
TD-NiCr	42,000	29,000	105	47,000	32,400	107	6
MAR-M 302	101,000	69,600	180	117,000	80,700	115	3
WI-52	84,000	57,900	168	111,000	76,500	126	7
X-40	56,000	38,600	--	86,000	59,300	123	20

Each result is the average of two tests.

TABLE 4. - STRESS-RUPTURE PROPERTIES AT 1800°F (982°C)

Alloy	Stress		Life (Nominal 100 hr)			Reduction of Area, %
	psi	N/cm^2	Hours		% of Nominal	
B1900	25,000	17,200	99	95	97	11
B1900 DID[a]	24,500	16,900	66.4	33.5	50	13.1
IN-100	25,000	17,200	94	70	82	16
IN-100 DS	23,000	15,900	144	164	154	62
MAR-M 200	26,000	17,900	114	73	94	10
Udimet 700 (wrought)	16,000	11,000	141	133	137	32
Udimet 700 (cast)	18,000	12,400	121	118	120	22
NX-188	14,000	9,650	117.8	141.1	130	1.7
NX-188 DS	20,000	13,800	60.1	54.8	58	24.7
WAZ-20	18,000	12,400	113.2	47.9	81	10.6
WAZ-20 DS	25,000	17,200	43.1	77.1	60	19.0
TAZ-8A	18,000	12,400	89	79	84	8
TAZ-8A DS	25,000	17,200	43.6	147.9	96	29.6
M22[a]	29,000	20,000	7.5	11	9.3	4
IN-713C[a]	21,000	14,500	75	54	64	22
IN-738[a]	20,000	13,800	22.5	21.7	22	13.1
IN-162	24,000	16,500	115	71	93	10
MAR-M 509	15,000	10,300	150.6	132.2	141	22.2
René 80	21,000	14,500	110.0	126.6	118	12.0
NASA VI A	29,800	20,500	71.5	75.6	74	6.9
TD-NiCr[a]	11,000	7,600	0.1		0.1	3
TD-NiCr[b]	5,000	3,400	1268		NA	6
MAR-M 302	14,000	9,700	69	95	82	8
WI-52	13,000	9,000	158	153	156	15
X-40	11,000	7,600	183	>105	183	33

[a]Rupture strength significantly lower than published data.
[b]Supplementary test.

TABLE 5. - SUMMARY OF TEST CONDITIONS FOR ALL SPECIMENS

Alloy and Condition	Number of Specimens at Test Temperatures 1915/525°F (1046/274°C)	1990/600°F (1088/316°C)	2065/675°F (1129/357°C)
B1900	1	1[a]	
B1900 + Jocoat		1[a]	2
B1900 DID + Jocoat		2	1
IN-100	1	1[a]	
IN-100 + Jocoat	1	1[a]	1
IN-100 + Xcoat A	1	1	1
IN-100 DS		1[a]	1
IN-100 DS + Jocoat		1[a]	1
MAR-M 200	1	1[a]	
MAR-M 200 + Jocoat		1	1
MAR-M 200 DS		1 + 1[a]	1
Udimet 700 wrought	1	1[a]	
Udimet 700 cast	1	1[a]	
Udimet 700 wrought, clad + Xcoat B (SEW)			1
NX-188		2	1
NX-188 + RT-1A coat		2	1
NX-188 DS		2	1
NX-188 DS + RT-1A coat		2	1
WAZ-20 + Jocoat		2	1
WAZ-20 DS + Jocoat		2	1
TAZ-8A	1	1 + 1[a]	1
TAZ-8A (SEW)		1	1
TAZ-8A clad + Xcoat B (SEW)			1
TAZ-8A DS		2	1
M22	1	1[a]	
IN 713C	1	1[a]	
IN 738	1	1	1
IN 162	1	1[a]	
MAR-M 509	1	1	1
René 80	1	1	1
RBH		1	1
NASA VI A	1	1	1
TD-NiCr	1	1[a]	1
MAR-M 302	1	1[a]	
WI-52	1	1[a]	
X-40	1	1[a]	1

[a]These specimens were tested in an earlier program and reported in Ref. 2.

TABLE 6. - CALIBRATION DATA FOR INSTRUMENTED IN-100 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	575	620	630	610	580	650	690	700	690	660	720	750	770	760	730
3	925	680	665	700	1020	1000	740	735	750	1100	1075	825	810	850	1170
6	1025	730	710	740	1100	1100	800	780	810	1170	1180	870	850	880	1250
9	1125	800	740	810	1200	1200	870	815	880	1290	1270	950	890	960	1355
12	1175	825	785	840	1275	1250	895	855	910	1350	1320	970	930	980	1425
15	1225	860	820	875	1325	1290	935	895	950	1390	1360	1000	965	1020	1450
30	1390	1050	1010	1060	1450	1460	1120	1080	1130	1530	1525	1190	1150	1200	1600
45	1525	1210	1180	1220	1575	1600	1280	1250	1290	1660	1675	1350	1320	1360	1735
1 0	1600	1340	1310	1350	1650	1680	1410	1385	1420	1730	1750	1485	1460	1500	1800
1 15	1700	1460	1440	1470	1730	1765	1530	1510	1540	1800	1840	1600	1580	1610	1870
1 30	1750	1580	1565	1590	1765	1825	1625	1610	1635	1840	1900	1700	1680	1710	1915
1 45	1790	1650	1640	1660	1800	1860	1700	1690	1710	1880	1935	1770	1760	1780	1950
2 0	1825	1720	1710	1730	1830	1900	1770	1760	1780	1915	1970	1840	1830	1850	1980
2 15	1850	1760	1750	1765	1855	1920	1815	1805	1820	1925	1990	1885	1875	1890	1995
2 30	1865	1800	1790	1805	1870	1940	1855	1845	1860	1945	2010	1935	1920	1940	2015
2 45	1880	1815	1805	1820	1885	1955	1885	1875	1890	1960	2025	1960	1950	1965	2030
3 0	1885	1830	1820	1835	1890	1960	1910	1900	1915	1965	2035	1975	1970	1980	2040

TABLE 7. - CALIBRATION DATA FOR INSTRUMENTED IN-100 SPECIMENS WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1840	1800	1810	1790	1830	1920	1880	1890	1870	1915	2000	1950	1960	1945	2000
3	1660	1755	1770	1740	1640	1730	1830	1850	1820	1740	1800	1900	1920	1890	1820
6	1600	1720	1730	1710	1520	1680	1770	1810	1760	1600	1750	1840	1880	1830	1675
9	1550	1680	1700	1660	1460	1625	1750	1780	1730	1530	1700	1820	1850	1800	1600
12	1510	1630	1670	1610	1420	1590	1700	1750	1680	1500	1660	1775	1820	1760	1575
15	1425	1610	1635	1590	1330	1550	1680	1715	1670	1460	1625	1750	1785	1735	1535
30	1300	1450	1475	1440	1230	1370	1520	1550	1510	1300	1440	1590	1620	1580	1375
45	1160	1300	1330	1290	1100	1235	1370	1405	1350	1165	1300	1440	1475	1420	1235
1 0	1040	1190	1215	1180	1000	1120	1265	1290	1250	1060	1190	1340	1360	1330	1130
1 15	950	1070	1090	1060	910	1030	1140	1165	1120	990	1100	1220	1235	1220	1060
1 30	860	970	985	950	830	940	1040	1060	1020	900	1010	1115	1130	1100	970
1 45	800	880	900	860	770	870	950	970	930	850	940	1020	1040	1010	920
2 0	730	770	800	760	710	810	860	880	850	790	880	930	950	920	860
2 15	680	725	740	715	670	760	800	815	790	750	830	875	890	865	820
2 30	640	675	690	665	630	715	750	760	745	705	790	810	830	800	780
2 45	610	640	645	630	600	685	710	720	705	680	760	780	790	770	755
3 0	590	620	625	610	580	665	690	700	685	660	730	750	770	760	735

TABLE 8. - CALIBRATION DATA FOR INSTRUMENTED IN 713C SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	540	575	585	565	535	620	650	665	640	610	700	735	745	725	695
3	1045	625	615	635	1115	1125	700	695	710	1185	1175	780	770	790	1265
6	1145	675	655	685	1195	1225	750	735	760	1275	1275	830	805	840	1345
9	1230	745	695	750	1270	1310	825	775	835	1350	1355	880	850	890	1420
12	1285	775	745	795	1315	1365	860	825	875	1400	1415	920	890	935	1470
15	1325	835	795	855	1345	1410	930	870	950	1430	1455	960	945	975	1510
30	1485	1090	1060	1095	1515	1570	1190	1140	1200	1600	1615	1225	1205	1240	1670
45	1605	1310	1285	1315	1630	1690	1390	1365	1400	1710	1735	1465	1450	1475	1780
1 0	1695	1495	1475	1550	1720	1775	1575	1555	1590	1795	1845	1640	1615	1650	1870
1 15	1760	1590	1580	1600	1775	1840	1675	1660	1685	1860	1900	1745	1730	1755	1925
1 30	1800	1685	1675	1690	1815	1880	1770	1755	1780	1895	1935	1825	1815	1830	1955
1 45	1835	1730	1720	1735	1845	1910	1810	1800	1820	1920	1970	1880	1870	1885	1985
2 0	1860	1785	1775	1790	1865	1935	1865	1855	1875	1940	2000	1935	1925	1940	2010
2 15	1870	1805	1795	1810	1875	1945	1885	1875	1890	1950	2010	1960	1950	1965	2020
2 30	1875	1835	1825	1840	1880	1950	1910	1900	1915	1955	2020	1980	1970	1985	2030
2 45	1885	1850	1840	1855	1890	1955	1925	1915	1930	1960	2030	2005	2000	2015	2040
3 0	1890	1855	1845	1860	1895	1960	1935	1925	1940	1965	2035	2020	2015	2025	2045

TABLE 9. - CALIBRATION DATA FOR INSTRUMENTED IN 713C SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1805	1845	1855	1835	1700	1885	1925	1935	1910	1750	1970	2015	2015	2020	1860
3	1655	1810	1835	1800	1550	1735	1880	1915	1870	1625	1815	1975	2000	1960	1655
6	1495	1795	1815	1775	1390	1575	1855	1895	1840	1475	1650	1950	1975	1925	1545
9	1405	1715	1755	1705	1310	1485	1800	1835	1780	1375	1560	1900	1930	1880	1490
12	1375	1670	1720	1660	1280	1455	1750	1800	1725	1350	1520	1830	1880	1810	1450
15	1325	1635	1685	1625	1230	1400	1715	1765	1700	1300	1475	1770	1835	1750	1400
30	1185	1435	1475	1425	1105	1265	1510	1555	1500	1180	1330	1660	1600	1645	1240
45	1045	1275	1305	1265	965	1120	1350	1385	1330	1030	1200	1370	1410	1360	1110
1 0	915	1115	1145	1105	845	1000	1200	1225	1180	930	1065	1240	1275	1230	1000
1 15	830	990	1015	980	780	910	1070	1095	1050	850	990	1115	1140	1100	930
1 30	765	880	905	875	715	840	970	990	950	805	920	1020	1040	1010	865
1 45	700	800	820	790	670	780	880	900	860	760	860	930	945	920	820
2 0	665	725	745	720	635	745	805	825	790	730	815	870	880	860	785
2 15	620	665	685	655	595	700	745	760	725	690	770	830	840	820	750
2 30	600	640	650	630	580	680	710	730	700	670	735	790	800	780	725
2 45	565	595	615	585	560	645	670	695	660	640	715	760	765	750	710
3 0	540	575	585	565	535	620	650	665	630	615	690	730	735	720	685

TABLE 10. - CALIBRATION DATA FOR INSTRUMENTED IN 162 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	595	625	635	620	585	665	695	700	690	655	730	765	775	760	720
3	1045	670	640	700	1135	1080	775	715	810	1170	1115	820	780	890	1245
6	1135	715	665	755	1205	1220	800	740	840	1275	1295	855	790	950	1375
9	1225	775	715	815	1295	1300	850	790	890	1370	1355	910	840	1010	1445
12	1285	815	755	855	1335	1355	890	830	930	1405	1425	970	900	1065	1520
15	1325	865	805	905	1385	1450	920	880	960	1510	1500	1020	960	1110	1575
30	1485	1125	1065	1165	1525	1560	1200	1140	1240	1600	1635	1290	1220	1350	1690
45	1615	1335	1285	1375	1645	1690	1410	1360	1450	1710	1750	1490	1430	1520	1780
1 0	1685	1495	1455	1525	1705	1760	1570	1530	1600	1760	1830	1635	1600	1680	1860
1 15	1735	1605	1575	1625	1740	1810	1660	1625	1680	1815	1880	1740	1715	1775	1915
1 30	1785	1670	1655	1695	1790	1850	1755	1730	1780	1855	1925	1815	1790	1820	1945
1 45	1815	1735	1725	1740	1820	1890	1880	1810	1830	1895	1965	1890	1875	1900	1980
2 0	1845	1775	1765	1785	1850	1920	1850	1840	1860	1925	1985	1925	1915	1935	2000
2 15	1855	1810	1800	1815	1860	1930	1885	1875	1890	1935	2000	1960	1950	1965	2010
2 30	1865	1845	1835	1855	1870	1940	1920	1960	1925	1945	2015	1995	1985	2000	2020
2 45	1875	1860	1850	1870	1880	1950	1935	1925	1940	1955	2025	2010	2000	2015	2030
3 0	1885	1870	1860	1875	1890	1960	1945	1935	1950	1965	2035	2020	2010	2025	2040

TABLE 11. - CALIBRATION DATA FOR INSTRUMENTED IN 162 SPECIMENS WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1645	1855	1865	1825	1565	1720	1920	1935	1900	1610	1930	2025	2040	1980	1820
3	1565	1805	1815	1745	1505	1635	1875	1885	1825	1565	1760	2005	2015	1930	1640
6	1500	1780	1790	1725	1445	1570	1850	1870	1780	1500	1680	1960	2000	1870	1560
9	1445	1760	1770	1685	1395	1520	1830	1860	1750	1440	1580	1910	1960	1815	1470
12	1400	1725	1735	1645	1355	1470	1800	1830	1720	1370	1510	1860	1915	1780	1400
15	1345	1685	1705	1605	1305	1420	1755	1795	1675	1340	1470	1810	1870	1720	1370
30	1145	1485	1525	1405	1115	1220	1555	1590	1475	1175	1290	1620	1660	1530	1230
45	1025	1275	1315	1245	995	1100	1350	1390	1310	1050	1145	1400	1440	1355	1100
1 0	925	1115	1135	1085	895	1000	1185	1205	1155	950	1035	1270	1310	1250	1010
1 15	845	1015	1035	975	825	920	1085	1105	1045	875	950	1140	1190	1130	930
1 30	765	925	945	885	755	835	1000	1020	980	800	880	1060	1080	1050	860
1 45	705	845	865	825	695	775	915	935	890	760	830	990	1015	980	815
2 0	685	785	805	765	675	755	855	875	835	745	790	915	930	905	780
2 15	665	735	745	715	655	725	810	830	790	715	765	825	835	820	755
2 30	645	685	695	665	635	695	755	765	740	685	745	795	805	790	740
2 45	615	650	660	640	605	675	725	735	720	670	735	780	790	775	730
3 0	595	625	635	620	585	665	700	700	690	660	730	765	775	760	720

TABLE 12. - CALIBRATION DATA FOR INSTRUMENTED MAR-M 509 SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	590	625	630	620	580	665	695	700	700	655	720	740	755	735	715
3	725	650	635	670	900	900	720	705	740	1150	1170	800	760	820	1350
6	1100	700	640	730	1190	1210	770	710	800	1300	1340	865	780	905	1440
9	1190	760	675	800	1265	1300	830	760	870	1375	1400	925	850	960	1480
12	1235	815	730	850	1315	1340	885	840	920	1420	1460	990	910	1045	1530
15	1290	880	800	910	1360	1400	950	870	980	1470	1510	1030	970	1090	1570
30	1460	1140	1060	1160	1515	1560	1210	1130	1240	1615	1660	1305	1250	1370	1720
45	1590	1340	1290	1380	1620	1680	1410	1360	1450	1710	1770	1515	1470	1560	1805
1 0	1670	1490	1450	1520	1700	1760	1560	1520	1590	1790	1850	1660	1600	1690	1875
1 15	1745	1600	1565	1615	1770	1820	1670	1640	1690	1845	1905	1760	1730	1790	1930
1 30	1780	1680	1660	1700	1800	1850	1750	1730	1770	1870	1945	1840	1820	1860	1970
1 45	1820	1750	1730	1760	1830	1890	1820	1800	1830	1900	1980	1915	1900	1925	2000
2 0	1850	1800	1780	1810	1855	1920	1870	1860	1880	1925	2010	1950	1940	1960	2015
2 15	1865	1825	1820	1830	1870	1935	1900	1895	1905	1940	2025	1985	1975	1995	2030
2 30	1875	1845	1840	1850	1880	1945	1920	1915	1925	1950	2035	2015	2005	2020	2040
2 45	1890	1865	1860	1870	1895	1960	1940	1935	1945	1965	2040	2025	2020	2030	2045
3 0	1900	1875	1870	1880	1905	1970	1955	1950	1960	1975	2045	2035	2030	2040	2050

TABLE 13. - CALIBRATION DATA FOR INSTRUMENTED MAR-M 509 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1810	1875	1870	1880	1700	1880	1950	1940	1960	1750	1950	2035	2030	2040	1820
3	1620	1840	1865	1820	1490	1690	1910	1935	1900	1550	1650	1985	2025	1960	1590
6	1510	1800	1840	1785	1390	1600	1870	1910	1855	1480	1580	1935	1990	1920	1510
9	1420	1760	1805	1740	1340	1490	1830	1875	1810	1410	1525	1900	1965	1875	1460
12	1370	1710	1765	1690	1300	1440	1780	1835	1760	1370	1480	1850	1925	1820	1410
15	1330	1670	1720	1650	1240	1400	1740	1790	1720	1310	1450	1815	1880	1785	1360
30	1150	1485	1520	1455	1075	1220	1540	1575	1520	1150	1300	1600	1650	1590	1200
45	1020	1300	1330	1280	980	1090	1355	1385	1335	1050	1150	1405	1450	1395	1070
1 0	920	1130	1175	1120	890	990	1185	1225	1170	960	1035	1240	1285	1230	990
1 15	840	1010	1050	1000	810	930	1060	1100	1050	900	960	1115	1150	1105	925
1 30	780	915	940	905	750	870	965	990	955	840	895	1010	1040	1005	860
1 45	720	835	850	825	700	790	885	900	875	770	820	940	960	935	815
2 0	680	770	780	765	660	750	820	830	815	730	790	870	890	865	785
2 15	650	725	735	720	630	720	775	785	770	700	745	820	840	815	740
2 30	620	680	690	675	610	690	720	730	715	680	735	790	805	785	730
2 45	600	645	650	640	590	670	705	710	700	660	725	760	775	755	720
3 0	590	625	630	620	580	660	690	695	685	650	720	740	755	735	715

TABLE 14. - CALIBRATION DATA FOR INSTRUMENTED RENÉ 80 SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	570	630	625	635	580	640	680	675	685	650	720	745	755	740	715
3	980	690	650	700	1075	1050	700	685	720	1110	1100	810	760	835	1210
6	1110	750	675	760	1170	1180	810	720	830	1240	1270	870	780	910	1350
9	1170	800	720	820	1250	1240	860	780	890	1310	1380	925	835	960	1420
12	1230	830	760	890	1290	1300	900	830	960	1360	1430	965	885	1030	1480
15	1280	870	805	940	1330	1350	940	875	1010	1400	1500	1030	935	1100	1530
30	1470	1130	1060	1180	1510	1540	1200	1130	1250	1580	1650	1330	1250	1390	1665
45	1590	1330	1280	1400	1610	1660	1400	1350	1445	1680	1750	1525	1460	1580	1770
1 0	1680	1490	1440	1535	1700	1750	1560	1510	1600	1770	1835	1660	1615	1700	1850
1 15	1750	1610	1575	1630	1760	1820	1680	1645	1700	1830	1895	1770	1735	1810	1905
1 30	1790	1700	1670	1730	1800	1860	1770	1740	1795	1870	1940	1840	1815	1860	1945
1 45	1835	1760	1740	1780	1845	1910	1830	1810	1850	1920	1965	1890	1880	1900	1970
2 0	1850	1795	1785	1805	1860	1925	1865	1850	1875	1935	1990	1940	1930	1950	1995
2 15	1860	1830	1820	1840	1870	1940	1900	1890	1910	1950	2015	1990	1985	1995	2020
2 30	1875	1855	1850	1860	1880	1950	1930	1925	1935	1955	2025	2000	1995	2005	2030
2 45	1885	1870	1865	1875	1890	1960	1945	1940	1940	1965	2030	2005	2000	2010	2035
3 0	1895	1880	1875	1885	1900	1970	1955	1950	1960	1975	2035	2010	2005	2015	2040

TABLE 15. - CALIBRATION DATA FOR INSTRUMENTED RENÉ 80 SPECIMENS WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1805	1855	1885	1840	1740	1865	1925	1960	1910	1800	1925	2000	2020	1990	1850
3	1605	1835	1875	1810	1550	1675	1910	1950	1885	1620	1745	1970	2000	1950	1700
6	1500	1780	1840	1760	1430	1570	1855	1915	1835	1500	1645	1925	1970	1910	1600
9	1450	1735	1800	1720	1380	1520	1810	1875	1790	1450	1575	1880	1930	1860	1535
12	1380	1690	1760	1660	1315	1450	1765	1835	1735	1385	1505	1830	1890	1810	1455
15	1330	1650	1715	1620	1280	1400	1725	1790	1690	1350	1460	1780	1850	1760	1410
30	1160	1450	1500	1415	1125	1230	1525	1575	1490	1195	1290	1580	1640	1560	1260
45	1035	1285	1320	1250	1010	1105	1360	1395	1330	1080	1180	1390	1430	1370	1135
1 0	915	1115	1150	1100	900	985	1190	1222	1175	970	1030	1230	1270	1200	1010
1 15	830	995	1030	980	820	900	1070	1105	1055	890	1000	1100	1130	1080	970
1 30	770	890	920	880	760	840	965	1000	955	830	890	1000	1030	980	870
1 45	720	780	800	770	710	790	855	875	845	780	840	930	950	925	820
2 0	675	730	740	720	665	745	805	815	795	735	800	870	885	865	780
2 15	630	700	710	695	625	700	775	788	770	695	780	830	840	825	770
2 30	610	660	665	655	605	680	735	740	730	675	775	795	805	790	760
2 45	595	645	650	640	590	665	720	725	715	660	770	780	790	775	745
3 0	580	635	640	630	575	650	710	715	705	645	720	770	780	765	715

TABLE 16. - CALIBRATION DATA FOR INSTRUMENTED X-40 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	595	625	630	625	585	665	680	700	680	650	735	770	775	765	725
3	965	675	645	680	1045	1000	745	715	750	1100	1035	815	785	825	1115
6	1045	725	695	730	1145	1100	800	770	810	1170	1135	870	840	880	1195
9	1125	795	745	800	1205	1175	870	815	880	1265	1240	925	885	935	1315
12	1165	855	805	865	1255	1235	925	875	935	1355	1310	1000	950	1010	1400
15	1225	945	885	955	1305	1300	1000	950	1010	1375	1395	1075	1025	1090	1470
30	1425	1160	1100	1170	1475	1500	1250	1170	1270	1550	1575	1300	1240	1310	1615
45	1575	1385	1325	1395	1615	1650	1460	1400	1470	1680	1710	1530	1470	1540	1745
1 0	1665	1515	1485	1525	1685	1735	1580	1550	1590	1750	1800	1650	1625	1660	1825
1 15	1725	1605	1595	1615	1735	1800	1690	1670	1700	1800	1865	1750	1740	1760	1875
1 30	1755	1685	1675	1695	1760	1825	1760	1750	1770	1830	1900	1835	1825	1845	1900
1 45	1805	1750	1745	1755	1810	1875	1825	1820	1835	1880	1950	1885	1880	1895	1950
2 0	1845	1800	1795	1805	1850	1915	1875	1870	1880	1920	1985	1945	1940	1950	1990
2 15	1865	1830	1825	1835	1870	1935	1905	1900	1910	1940	2000	1965	1960	1970	2010
2 30	1885	1860	1855	1865	1890	1950	1925	1920	1930	1955	2025	1990	1985	1995	2030
2 45	1890	1875	1870	1880	1895	1955	1945	1940	1950	1960	2030	2015	2010	2020	2035
3 0	1895	1890	1885	1895	1900	1960	1960	1955	1965	1970	2035	2030	2025	2035	2040

TABLE 17. - CALIBRATION DATA FOR INSTRUMENTED X-40 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1725	1870	1890	1860	1665	1850	1930	1950	1920	1770	1985	2000	2010	1990	1885
3	1605	1825	1845	1815	1525	1710	1900	1915	1890	1625	1815	1975	1990	1970	1715
6	1525	1785	1805	1775	1465	1610	1850	1875	1845	1530	1700	1925	1950	1915	1625
9	1465	1730	1750	1720	1405	1550	1805	1825	1795	1475	1635	1880	1900	1875	1545
12	1425	1680	1710	1670	1365	1500	1750	1780	1740	1425	1575	1820	1850	1810	1475
15	1375	1635	1665	1625	1305	1440	1700	1735	1690	1375	1500	1770	1800	1760	1450
30	1205	1425	1455	1415	1125	1275	1500	1525	1490	1200	1345	1570	1600	1560	1270
45	1055	1200	1270	1190	1005	1175	1280	1350	1270	1075	1250	1375	1425	1360	1150
1 0	945	1090	1120	1080	905	1020	1170	1200	1160	975	1100	1230	1260	1220	1050
1 15	865	980	1000	970	835	935	1050	1075	1040	900	1000	1130	1145	1120	975
1 30	795	890	905	880	765	860	960	975	950	840	930	1030	1050	1020	900
1 45	735	810	825	800	715	810	880	900	870	790	880	955	975	950	860
2 0	695	755	765	750	675	765	825	835	820	750	835	890	900	885	825
2 15	665	695	705	695	645	735	765	775	760	725	800	840	850	835	790
2 30	635	655	665	655	620	700	725	735	720	695	790	790	800	785	770
2 45	615	640	645	640	610	685	710	715	705	675	755	780	785	775	750
3 0	595	625	630	625	585	665	695	700	690	655	735	770	775	765	725

TABLE 18. - CALIBRATION DATA FOR INSTRUMENTED B1900 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	585	600	610	595	575	655	670	680	665	645	725	740	750	735	715
3	920	640	610	670	1075	990	710	680	740	1185	1200	780	750	800	1285
6	1050	700	635	730	1185	1120	770	705	800	1275	1320	840	795	870	1375
9	1140	750	690	790	1270	1210	820	760	860	1360	1375	915	845	945	1450
12	1200	800	750	860	1340	1270	870	820	920	1415	1430	990	925	1010	1500
15	1260	860	800	915	1390	1330	930	870	980	1460	1480	1045	990	1080	1550
30	1440	1140	1080	1195	1530	1510	1210	1150	1260	1600	1625	1335	1290	1360	1680
45	1560	1340	1300	1390	1620	1630	1410	1370	1460	1690	1730	1530	1510	1555	1780
1 0	1640	1500	1470	1530	1700	1710	1570	1540	1600	1770	1820	1680	1655	1695	1865
1 15	1705	1605	1585	1630	1750	1775	1675	1655	1700	1830	1900	1780	1765	1795	1930
1 30	1770	1690	1680	1700	1800	1840	1760	1750	1780	1870	1935	1860	1845	1875	1970
1 45	1820	1740	1730	1750	1840	1890	1810	1800	1820	1910	1970	1920	1905	1930	1990
2 0	1850	1790	1780	1795	1870	1920	1860	1850	1870	1940	1995	1960	1950	1970	2010
2 15	1860	1825	1815	1830	1875	1930	1895	1885	1900	1945	2010	1990	1980	1995	2020
2 30	1870	1850	1840	1855	1880	1940	1920	1910	1925	1950	2015	2000	1990	2005	2025
2 45	1875	1860	1850	1865	1885	1945	1930	1920	1935	1955	2020	2010	2000	2015	2030
3 0	1880	1870	1860	1875	1890	1950	1940	1930	1945	1960	2025	2015	2005	2020	2035

TABLE 19. - CALIBRATION DATA FOR INSTRUMENTED B1900 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1770	1850	1860	1840	1610	1830	1920	1930	1910	1670	1900	2010	2005	2000	1760
3	1595	1820	1850	1800	1500	1655	1890	1920	1870	1560	1770	1980	1995	1970	1670
6	1510	1800	1830	1775	1410	1570	1870	1900	1845	1470	1660	1955	1980	1940	1585
9	1440	1750	1805	1725	1350	1500	1820	1875	1795	1410	1575	1930	1960	1900	1510
12	1370	1720	1755	1690	1300	1430	1790	1825	1760	1360	1510	1875	1920	1855	1460
15	1330	1680	1715	1650	1250	1390	1750	1785	1720	1310	1460	1835	1880	1810	1405
30	1150	1470	1510	1440	1100	1210	1540	1580	1510	1160	1275	1610	1635	1580	1225
45	1020	1275	1310	1250	980	1080	1345	1380	1320	1040	1075	1410	1430	1380	1050
1 0	900	1105	1135	1085	870	960	1175	1205	1155	930	1025	1230	1250	1215	995
1 15	820	975	995	960	790	880	1045	1065	1030	850	965	1100	1110	1085	900
1 30	760	890	900	870	735	840	950	970	935	815	925	960	975	950	840
1 45	700	800	815	785	680	760	870	885	855	740	815	885	900	875	795
2 0	660	735	750	720	640	720	805	820	795	700	785	825	840	815	765
2 15	625	690	705	680	610	685	760	775	750	670	760	790	800	780	750
2 30	605	660	670	650	595	665	730	740	720	655	745	770	780	760	735
2 45	595	625	635	620	585	655	695	705	690	645	730	750	760	745	720
3 0	585	600	610	595	575	645	670	680	660	635	725	740	750	735	715

TABLE 20. - CALIBRATION DATA FOR INSTRUMENTED B1900 DID + JOCOAT SPECIMENS
WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	575	585	595	580	565	650	660	670	655	640	720	730	735	725	710
3	940	600	590	630	1190	1020	675	675	705	1230	1100	740	735	790	1250
6	1110	660	610	690	1325	1165	735	685	775	1340	1225	800	760	855	1360
9	1210	720	650	760	1375	1260	795	720	835	1425	1310	865	825	920	1470
12	1275	790	720	825	1425	1335	865	790	900	1475	1380	930	885	990	1530
15	1325	850	785	890	1450	1400	925	860	965	1530	1475	1005	960	1075	1610
30	1470	1160	1090	1200	1580	1500	1235	1165	1275	1655	1630	1325	1280	1365	1740
45	1580	1370	1310	1420	1665	1655	1445	1385	1490	1740	1750	1540	1510	1580	1820
1 0	1675	1525	1480	1550	1730	1750	1600	1555	1625	1800	1840	1690	1670	1710	1890
1 15	1740	1630	1595	1650	1800	1815	1700	1665	1720	1870	1900	1795	1775	1810	1935
1 30	1780	1700	1670	1725	1820	1855	1775	1745	1795	1890	1950	1865	1850	1880	1980
1 45	1820	1760	1735	1780	1835	1895	1835	1810	1850	1910	1980	1910	1895	1925	1995
2 0	1840	1810	1790	1825	1850	1915	1885	1865	1895	1925	2000	1955	1940	1970	2010
2 15	1860	1835	1820	1845	1865	1935	1910	1895	1920	1940	2020	1980	1970	1990	2025
2 30	1870	1850	1840	1855	1875	1945	1925	1915	1930	1950	2030	2000	1990	2010	2035
2 45	1875	1860	1850	1865	1880	1950	1935	1925	1940	1955	2035	2020	2010	2025	2040
3 0	1880	1870	1860	1875	1885	1955	1945	1935	1950	1960	2040	2030	2020	2035	2045

TABLE 21. - CALIBRATION DATA FOR INSTRUMENTED B1900 DID + JOCOAT SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1630	1840	1860	1830	1440	1690	1915	1935	1900	1500	1760	1990	2000	1965	1565
3	1530	1810	1835	1795	1360	1590	1885	1910	1870	1435	1660	1955	1980	1930	1485
6	1440	1765	1800	1750	1280	1510	1840	1875	1825	1355	1590	1915	1950	1875	1425
9	1390	1720	1760	1695	1225	1450	1795	1835	1770	1300	1520	1860	1910	1825	1360
12	1320	1670	1700	1650	1170	1390	1745	1775	1725	1245	1465	1810	1850	1770	1320
15	1265	1615	1650	1600	1125	1340	1690	1730	1675	1200	1310	1760	1805	1725	1280
30	1070	1365	1410	1330	970	1140	1440	1485	1410	1040	1230	1520	1560	1490	1115
45	930	1150	1175	1115	830	1000	1225	1250	1195	900	1100	1320	1355	1290	990
1 0	830	980	1000	965	750	900	1055	1075	1040	820	990	1160	1190	1130	890
1 15	745	870	890	855	695	820	945	965	930	770	910	1030	1060	1015	840
1 30	690	790	810	775	650	765	865	885	840	725	850	940	970	920	810
1 45	640	715	735	705	610	715	790	810	775	690	795	865	890	850	765
2 0	610	665	680	650	585	685	735	750	720	665	765	815	840	805	745
2 15	585	640	650	630	580	660	715	725	705	655	740	785	795	775	730
2 30	575	610	620	600	570	650	685	695	675	645	730	755	760	745	725
2 45	570	595	605	590	565	645	670	680	665	640	725	740	745	735	720
3 0	565	585	595	580	560	640	660	670	655	635	720	730	735	725	710

TABLE 22. - CALIBRATION DATA FOR INSTRUMENTED NX-188 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	570	590	600	580	560	630	650	660	640	620	695	715	725	705	685
3	950	650	600	680	1130	1010	710	660	740	1190	1105	770	725	810	1200
6	1100	715	650	750	1250	1160	775	700	810	1310	1230	835	760	880	1370
9	1230	780	700	810	1325	1280	840	760	870	1385	1330	920	820	960	1440
12	1280	840	750	885	1375	1330	900	810	945	1435	1400	1000	910	1050	1500
15	1350	900	820	950	1420	1410	960	880	1010	1480	1460	1080	1000	1125	1540
30	1500	1190	1110	1220	1570	1560	1250	1170	1280	1630	1620	1370	1300	1400	1680
45	1630	1400	1250	1410	1670	1690	1460	1310	1470	1730	1730	1560	1520	1585	1780
1 0	1680	1535	1510	1560	1720	1740	1595	1570	1620	1780	1820	1705	1680	1725	1860
1 15	1740	1640	1625	1660	1770	1800	1700	1685	1720	1830	1895	1810	1790	1830	1925
1 30	1780	1710	1700	1720	1815	1840	1770	1760	1780	1875	1950	1890	1880	1895	1965
1 45	1820	1770	1750	1780	1850	1885	1835	1815	1845	1915	1975	1940	1930	1945	1990
2 0	1840	1820	1800	1830	1860	1905	1885	1865	1895	1925	2000	1975	1970	1980	2010
2 15	1855	1835	1825	1845	1870	1920	1900	1890	1910	1935	2010	2005	2000	2010	2020
2 30	1865	1850	1840	1855	1875	1935	1920	1910	1925	1945	2020	2015	2010	2020	2025
2 45	1875	1860	1850	1865	1880	1945	1930	1920	1935	1950	2025	2020	2015	2025	2030
3 0	1880	1865	1855	1870	1885	1950	1935	1925	1940	1955	2030	2025	2020	2030	2035

TABLE 23. - CALIBRATION DATA FOR INSTRUMENTED NX-188 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1660	1860	1855	1855	1580	1730	1930	1925	1920	1650	1810	2005	2020	1985	1730
3	1570	1840	1850	1825	1485	1640	1910	1920	1895	1555	1730	1970	2015	1950	1640
6	1490	1805	1840	1770	1410	1560	1875	1910	1840	1480	1660	1930	1965	1910	1575
9	1425	1760	1800	1720	1360	1495	1830	1870	1790	1430	1600	1890	1925	1865	1520
12	1375	1695	1750	1670	1300	1445	1765	1820	1740	1370	1540	1840	1880	1810	1475
15	1320	1640	1685	1620	1260	1390	1710	1755	1690	1330	1480	1790	1830	1740	1430
30	1110	1400	1440	1380	1040	1180	1470	1510	1450	1110	1270	1530	1560	1490	1220
45	960	1190	1230	1170	915	1030	1260	1300	1240	985	1110	1310	1340	1285	1070
1 0	860	1020	1060	1000	825	930	1090	1130	1070	895	1000	1145	1170	1120	960
1 15	790	900	930	880	755	860	970	1000	950	825	915	1015	1040	1000	890
1 30	725	810	840	790	700	795	880	910	860	770	830	920	940	905	810
1 45	670	730	760	715	650	740	810	830	785	720	795	860	880	845	770
2 0	630	680	700	665	610	700	750	770	735	680	760	820	830	805	750
2 15	605	640	665	630	590	675	715	735	705	660	740	780	790	770	730
2 30	585	620	630	610	570	655	690	700	680	640	720	750	760	740	710
2 45	575	605	615	595	565	645	675	685	665	635	705	730	740	720	695
3 0	570	590	600	580	560	640	660	670	650	630	695	715	725	705	685

TABLE 24. - CALIBRATION DATA FOR INSTRUMENTED TAZ-8A DS SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	605	640	650	635	600	665	700	710	695	660	725	745	755	740	720
3	1070	685	655	780	1120	1130	745	715	840	1180	950	800	760	880	1100
6	1160	760	675	840	1220	1220	820	735	900	1280	1270	860	780	960	1320
9	1230	815	730	900	1290	1290	875	790	960	1350	1360	920	840	1025	1405
12	1290	885	775	940	1350	1350	945	835	1000	1410	1420	990	900	1090	1475
15	1340	950	840	1000	1390	1400	1010	900	1060	1450	1475	1050	960	1145	1520
30	1500	1220	1125	1260	1550	1570	1290	1195	1330	1620	1650	1350	1260	1425	1680
45	1600	1410	1340	1460	1650	1670	1480	1410	1530	1720	1760	1560	1510	1640	1785
1 0	1690	1550	1500	1580	1710	1760	1620	1570	1650	1780	1850	1705	1665	1735	1880
1 15	1760	1640	1615	1675	1780	1830	1710	1685	1745	1850	1910	1800	1765	1830	1925
1 30	1805	1720	1700	1745	1815	1875	1790	1770	1815	1885	1955	1875	1845	1900	1965
1 45	1830	1780	1760	1790	1840	1900	1850	1830	1860	1910	1980	1925	1900	1950	1990
2 0	1850	1810	1800	1820	1855	1920	1880	1890	1890	1925	2000	1970	1955	1985	2010
2 15	1860	1845	1840	1850	1865	1930	1925	1920	1920	1935	2015	1995	1980	2005	2020
2 30	1870	1865	1860	1870	1875	1940	1935	1930	1940	1945	2025	2020	2005	2015	2030
2 45	1880	1875	1870	1880	1885	1950	1945	1940	1950	1955	2035	2020	2015	2025	2040
3 0	1890	1885	1880	1890	1895	1960	1955	1950	1960	1965	2040	2025	2020	2030	2045

TABLE 25. - CALIBRATION DATA FOR INSTRUMENTED TAZ-8A DS SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1680	1860	1880	1850	1620	1740	1920	1940	1910	1670	1800	2000	2020	1980	1725
3	1580	1825	1870	1785	1540	1640	1885	1930	1845	1590	1700	1950	2010	1935	1650
6	1520	1800	1835	1760	1490	1580	1860	1895	1820	1540	1630	1910	1975	1885	1570
9	1460	1760	1800	1720	1420	1520	1820	1860	1780	1470	1580	1870	1945	1835	1510
12	1400	1725	1760	1680	1370	1460	1785	1820	1740	1420	1525	1820	1910	1785	1450
15	1350	1680	1720	1645	1320	1410	1740	1780	1705	1360	1500	1770	1870	1735	1400
30	1180	1465	1510	1445	1140	1240	1525	1570	1505	1190	1320	1560	1645	1535	1235
45	1060	1285	1310	1260	1030	1120	1345	1370	1320	1070	1200	1405	1450	1370	1110
1 0	950	1140	1170	1120	920	1010	1200	1230	1180	970	1065	1250	1275	1210	1010
1 15	860	1015	1035	1000	830	920	1075	1095	1060	880	975	1100	1125	1075	930
1 30	800	925	935	900	775	860	985	995	960	825	890	1000	1020	985	870
1 45	740	850	870	830	725	800	910	930	890	780	830	930	955	920	850
2 0	710	770	795	760	700	770	830	855	820	760	800	870	890	860	820
2 15	665	730	740	720	660	725	790	800	780	720	760	820	840	810	770
2 30	640	695	705	690	635	700	755	760	750	695	745	790	800	785	740
2 45	625	650	660	645	620	685	715	720	710	680	735	760	770	755	730
3 0	605	640	650	635	600	665	700	710	695	660	725	745	755	740	720

TABLE 26. - CALIBRATION DATA FOR INSTRUMENTED WAZ-20 SPECIMENS

WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	575	590	595	585	565	650	665	670	660	640	720	735	740	730	710
3	900	620	595	630	1160	965	695	670	705	1210	1030	750	740	765	1270
6	1060	665	600	690	1285	1110	710	675	735	1330	1165	790	760	820	1370
9	1140	730	635	770	1360	1200	770	700	800	1400	1260	850	800	880	1450
12	1210	800	710	840	1415	1260	830	780	870	1460	1320	915	865	950	1500
15	1265	870	775	920	1460	1325	910	850	960	1500	1380	990	925	1020	1540
30	1460	1190	1115	1235	1610	1510	1240	1170	1290	1660	1555	1300	1210	1325	1715
45	1610	1430	1370	1470	1700	1660	1480	1420	1520	1750	1700	1535	1475	1560	1810
1 0	1700	1570	1530	1600	1760	1750	1640	1590	1670	1810	1800	1690	1655	1710	1880
1 15	1770	1670	1630	1700	1825	1820	1730	1690	1760	1875	1880	1800	1775	1815	1925
1 30	1825	1770	1730	1780	1850	1875	1830	1800	1840	1900	1925	1880	1860	1890	1960
1 45	1850	1810	1800	1820	1870	1920	1870	1860	1880	1930	1985	1930	1920	1940	2005
2 0	1860	1845	1835	1850	1875	1930	1910	1900	1915	1940	2015	1960	1965	1970	2020
2 15	1870	1865	1860	1865	1880	1940	1935	1930	1940	1945	2020	1980	2000	1990	2025
2 30	1875	1870	1865	1875	1885	1945	1940	1935	1945	1950	2025	2000	2015	2005	2030
2 45	1880	1875	1870	1880	1888	1950	1945	1940	1950	1955	2030	2020	2020	2025	2035
3 0	1885	1880	1875	1885	1890	1955	1950	1945	1955	1960	2035	2030	2025	2035	2040

TABLE 27. - CALIBRATION DATA FOR INSTRUMENTED WAZ-20 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1780	1870	1875	1860	1650	1830	1925	1935	1915	1690	1880	1980	2000	1960	1730
3	1710	1865	1870	1855	1510	1760	1910	1930	1900	1560	1810	1950	1990	1910	1600
6	1560	1835	1865	1820	1420	1610	1890	1925	1875	1460	1670	1910	1975	1880	1500
9	1475	1790	1850	1770	1375	1535	1830	1910	1810	1420	1585	1860	1940	1850	1450
12	1410	1750	1810	1720	1260	1460	1790	1870	1770	1300	1520	1830	1900	1810	1340
15	1360	1700	1760	1665	1205	1415	1750	1820	1720	1250	1470	1800	1855	1760	1300
30	1155	1450	1505	1405	1030	1210	1500	1555	1460	1070	1265	1540	1600	1500	1100
45	1025	1240	1285	1200	925	1060	1290	1335	1250	950	1100	1340	1380	1300	990
1 0	915	1075	1120	1050	835	955	1125	1170	1100	875	1000	1175	1220	1150	910
1 15	815	940	975	915	750	865	1000	1030	975	790	910	1050	1085	1025	830
1 30	735	840	865	810	680	795	890	915	865	730	850	950	970	930	780
1 45	690	760	785	740	635	745	820	845	800	685	800	885	910	865	750
2 0	650	700	710	680	600	710	760	780	740	660	770	830	840	810	735
2 15	620	650	675	630	590	690	720	745	700	645	740	785	810	765	725
2 30	600	620	640	600	575	670	690	710	670	640	730	755	775	745	720
2 45	585	600	615	590	570	650	670	685	660	635	725	745	750	740	715
3 0	575	590	595	585	565	640	660	665	655	630	720	735	740	730	710

TABLE 28. - CALIBRATION DATA FOR INSTRUMENTED IN 738 SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	600	630	640	625	590	670	700	710	695	660	720	730	740	725	700
3	915	680	645	735	1225	985	750	715	805	1325	1130	800	740	835	1475
6	1130	730	650	790	1360	1200	800	720	860	1480	1300	885	760	920	1600
9	1210	805	700	865	1430	1280	875	770	935	1530	1390	970	845	995	1650
12	1280	880	760	930	1480	1350	950	830	1000	1550	1470	1065	925	1085	1700
15	1330	950	830	995	1520	1400	1020	900	1065	1590	1510	1145	1000	1180	1735
30	1510	1250	1150	1285	1650	1580	1320	1220	1365	1720	1670	1435	1345	1460	1840
45	1665	1490	1400	1520	1750	1725	1560	1470	1590	1820	1800	1640	1570	1660	1900
1 0	1750	1640	1570	1650	1790	1820	1710	1630	1720	1860	1880	1775	1735	1805	1955
1 15	1810	1730	1695	1740	1850	1880	1800	1765	1810	1920	1960	1870	1840	1880	2000
1 30	1840	1785	1770	1795	1860	1910	1855	1835	1860	1930	1990	1955	1930	1970	2010
1 45	1855	1840	1815	1850	1870	1925	1920	1900	1920	1940	2005	1990	1970	2000	2020
2 0	1865	1860	1850	1875	1880	1935	1935	1925	1945	1950	2015	2010	2000	2020	2030
2 15	1875	1875	1870	1880	1890	1945	1945	1940	1950	1955	2025	2020	2015	2025	2040
2 30	1890	1880	1875	1885	1895	1955	1950	1945	1955	1960	2035	2030	2025	2035	2045
2 45	1893	1885	1880	1890	1898	1960	1955	1950	1960	1965	2040	2035	2030	2040	2048
3 0	1895	1890	1885	1895	1900	1965	1960	1955	1965	1970	2045	2040	2035	2045	2050

TABLE 29. - CALIBRATION DATA FOR INSTRUMENTED IN 738 SPECIMENS

WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1700	1870	1885	1860	1530	1770	1940	1955	1930	1600	1870	2025	2030	2015	1730
3	1600	1835	1880	1810	1450	1670	1905	1950	1880	1520	1820	2010	2025	1985	1550
6	1550	1800	1855	1775	1360	1620	1870	1925	1845	1430	1750	1980	2010	1950	1420
9	1500	1765	1820	1740	1300	1570	1835	1890	1810	1370	1700	1940	1980	1910	1360
12	1450	1730	1785	1710	1270	1520	1800	1855	1780	1340	1650	1900	1930	1870	1300
15	1410	1690	1740	1665	1220	1480	1760	1810	1735	1290	1590	1840	1900	1825	1260
30	1200	1490	1550	1470	1020	1270	1560	1620	1540	1090	1360	1625	1675	1600	1100
45	1060	1285	1340	1260	910	1130	1355	1410	1330	980	1210	1430	1465	1390	1010
1 0	930	1110	1155	1100	810	1000	1180	1185	1170	880	1080	1260	1300	1235	925
1 15	830	980	1020	970	730	900	1050	1090	1040	800	970	1125	1160	1110	870
1 30	760	870	905	860	680	830	940	965	930	750	910	1020	1040	1000	830
1 45	710	790	810	780	650	780	860	880	850	720	850	935	950	920	780
2 0	665	730	750	720	635	735	800	820	790	705	805	875	885	865	760
2 15	635	675	700	665	620	705	745	765	735	690	770	800	810	790	740
2 30	615	650	670	645	605	685	720	740	715	675	750	760	770	750	725
2 45	605	640	650	635	595	675	710	720	705	665	735	740	750	735	710
3 0	600	630	640	625	590	670	700	710	695	660	720	730	740	725	700

TABLE 30. - CALIBRATION DATA FOR INSTRUMENTED NASA VI A SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	590	615	625	605	575	650	680	685	675	640	710	735	745	725	700
3	940	675	625	710	1380	990	680	685	715	1410	1050	770	745	790	1435
6	1170	725	650	770	1460	1210	770	710	800	1510	1250	820	750	850	1555
9	1270	790	695	835	1530	1330	840	755	880	1580	1390	890	800	930	1625
12	1340	860	750	900	1575	1400	910	800	960	1625	1470	960	850	1020	1675
15	1390	925	805	985	1615	1450	975	860	1035	1665	1510	1025	915	1100	1720
30	1560	1240	1130	1280	1720	1620	1300	1190	1340	1785	1685	1355	1250	1410	1850
45	1665	1450	1360	1480	1790	1735	1510	1430	1550	1860	1800	1580	1500	1620	1930
1 0	1760	1600	1535	1625	1840	1830	1665	1605	1685	1905	1885	1725	1670	1760	1980
1 15	1820	1700	1660	1720	1865	1890	1770	1730	1790	1930	1945	1835	1780	1860	2010
1 30	1840	1775	1740	1785	1875	1910	1840	1810	1850	1935	1980	1905	1865	1920	2020
1 45	1865	1810	1805	1830	1880	1935	1900	1875	1910	1940	2000	1955	1920	1970	2025
2 0	1875	1850	1835	1860	1885	1945	1920	1905	1930	1945	2010	1985	1975	2000	2030
2 15	1880	1870	1860	1880	1890	1950	1940	1930	1950	1950	2020	2000	2000	2010	2035
2 30	1885	1880	1875	1885	1895	1955	1950	1945	1955	1955	2030	2020	2015	2025	2040
2 45	1890	1885	1880	1890	1898	1960	1955	1950	1960	1958	2035	2030	2025	2035	2045
3 0	1895	1890	1885	1895	1900	1965	1960	1955	1965	1960	2040	2035	2030	2040	2050

TABLE 31. - CALIBRATION DATA FOR INSTRUMENTED NASA VI A SPECIMENS WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1705	1870	1885	1840	1425	1785	1940	1955	1915	1520	1880	2005	2030	1985	1650
3	1605	1845	1880	1805	1350	1675	1915	1950	1875	1420	1740	1980	2025	1945	1490
6	1525	1815	1850	1760	1290	1585	1885	1920	1830	1340	1640	1940	2005	1905	1390
9	1450	1765	1815	1705	1235	1520	1835	1885	1775	1285	1580	1915	1970	1870	1330
12	1370	1710	1775	1660	1185	1450	1780	1845	1730	1230	1525	1865	1935	1825	1260
15	1340	1670	1740	1615	1135	1400	1740	1810	1685	1185	1475	1825	1885	1775	1220
30	1170	1450	1520	1420	960	1230	1520	1590	1490	1015	1300	1610	1675	1570	1070
45	1020	1270	1330	1250	870	1090	1340	1400	1320	920	1170	1415	1480	1385	960
1 0	900	1105	1170	1085	790	970	1175	1240	1155	840	1050	1250	1305	1225	885
1 15	825	980	1020	960	720	885	1050	1090	1030	790	970	1125	1160	1105	850
1 30	755	890	920	870	680	815	960	990	940	750	900	1025	1060	1005	820
1 45	710	810	830	790	640	770	875	895	855	700	845	935	960	925	775
2 0	680	750	765	735	610	740	810	825	795	675	800	870	885	860	750
2 15	650	700	715	690	600	710	760	775	750	665	770	815	830	805	730
2 30	620	670	680	660	590	680	730	740	720	655	750	780	800	770	720
2 45	600	630	640	620	580	660	695	705	685	645	730	750	765	745	710
3 0	590	615	625	605	575	650	675	685	665	640	710	735	745	725	700

TABLE 32. - CALIBRATION DATA FOR INSTRUMENTED TAZ-8A (SINGLE EDGE WEDGE) SPECIMENS WHEN CYCLED INTO THE HIGH TEMPERATURE BED

Time,	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
min-sec	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	625	600	625	620	575	700	675	700	690	645	765	740	765	760	715
3	625	740	625	690	1020	700	810	700	770	1040	765	870	765	830	1040
6	640	820	645	770	1110	710	890	715	840	1140	770	950	775	910	1190
9	670	880	675	840	1180	740	950	745	910	1230	800	1020	805	980	1270
12	720	930	725	900	1230	790	1000	795	970	1280	840	1080	850	1040	1320
15	770	995	775	950	1270	840	1065	845	1025	1320	890	1140	900	1100	1360
30	1040	1210	1045	1190	1420	1110	1280	1115	1090	1480	1175	1355	1185	1325	1550
45	1260	1390	1275	1370	1530	1330	1460	1340	1440	1600	1400	1530	1410	1510	1675
1 0	1335	1530	1355	1510	1630	1410	1600	1430	1580	1700	1570	1685	1580	1665	1770
1 15	1575	1640	1585	1630	1700	1650	1710	1660	1690	1770	1710	1780	1720	1770	1850
1 30	1660	1710	1675	1700	1750	1730	1780	1740	1760	1820	1800	1860	1810	1850	1910
1 45	1725	1760	1735	1750	1790	1800	1830	1810	1820	1860	1865	1920	1875	1910	1950
2 0	1780	1800	1790	1790	1825	1850	1870	1860	1860	1900	1920	1965	1930	1955	1970
2 15	1810	1825	1815	1815	1845	1880	1905	1885	1895	1920	1960	1970	1965	1960	1990
2 30	1835	1845	1835	1835	1860	1910	1925	1910	1920	1930	1985	1990	1990	1980	2010
2 45	1850	1860	1850	1850	1870	1920	1940	1920	1930	1940	2000	2010	2000	2000	2020
3 0	1860	1870	1860	1865	1880	1930	1945	1930	1940	1950	2010	2020	2010	2015	2030

TABLE 33. - CALIBRATION DATA FOR INSTRUMENTED TAZ-8A (SINGLE EDGE WEDGE) SPECIMENS WHEN CYCLED INTO THE INTERMEDIATE TEMPERATURE BED

Time, min-sec	Temperature, °F, at Each Couple Position														
	1915/525°F Cycle					1990/600°F Cycle					2065/675°F Cycle				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1860	1800	1860	1830	1670	1920	1840	1920	1860	1725	1995	1880	1995	1910	1780
3	1850	1750	1850	1770	1580	1910	1800	1910	1810	1630	1975	1840	1970	1860	1670
6	1830	1715	1820	1735	1510	1890	1750	1885	1760	1560	1950	1790	1945	1810	1600
9	1805	1670	1795	1695	1450	1865	1710	1860	1720	1500	1920	1745	1910	1765	1550
12	1775	1615	1765	1640	1400	1830	1650	1820	1660	1450	1870	1690	1860	1710	1500
15	1725	1580	1715	1605	1360	1780	1610	1770	1630	1410	1830	1645	1820	1680	1460
30	1520	1360	1510	1380	1175	1570	1410	1560	1430	1225	1615	1460	1605	1480	1275
45	1315	1190	1305	1210	1030	1365	1240	1355	1260	1090	1410	1280	1400	1300	1150
1 0	1145	1040	1135	1070	910	1200	1080	1190	1100	975	1250	1120	1240	1140	1040
1 15	1000	930	990	950	820	1050	970	1040	990	875	1110	1000	1100	1020	930
1 30	900	840	890	860	760	950	880	940	900	810	1000	910	990	930	860
1 45	830	775	825	795	705	880	810	875	830	755	920	845	915	865	810
2 0	770	720	765	740	670	830	760	825	780	725	860	800	855	820	780
2 15	710	675	705	695	640	765	725	760	750	695	820	770	820	790	750
2 30	660	640	660	660	605	730	700	730	720	675	800	760	800	780	735
2 45	640	620	640	640	590	700	685	700	705	660	780	750	780	770	725
3 0	625	600	625	620	575	695	670	695	690	645	765	740	765	760	715

TABLE 34. - TOTAL THERMAL CYCLES FOR EACH SPECIMEN

Alloy and Condition	Total Cycles (3 min dwell in fluidized beds) 2065/675°F (1129/357°C)	1915/525°F (1046/274°C)	1990/600°F (1088/316°C)
B1900	-	600	-
B1900 + Jocoat	1300, 1700	-	-
B1900 DID + Jocoat	2300	-	3250, 1200
IN-100	-	200	-
IN-100 + Jocoat	300	500	-
IN-100 + Xcoat A	200	500	470
IN-100 DS	2400	-	-
IN-100 DS + Jocoat	2200	-	-
MAR-M 200	-	200	-
MAR-M 200 + Jocoat	550	-	470
MAR-M 200 DS	2400	-	4000
Udimet 700 wrought	-	200	-
Udimet 700 cast	-	500	-
Udimet 700 wrought, clad + Xcoat B (SEW)	1300	-	-
NX-188	500	-	500, 700
NX-188 + RT-1A coat	1100	-	700, 1200
NX-188 DS	6500	-	6250[a]
NX-188 DS + RT-1A coat	6100	-	6250[a]
WAZ-20 + Jocoat	50	-	700[a]
WAZ-20 DS + Jocoat	6100	-	5500[a]
TAZ-8A	1100	600	1200
TAZ-8A (SEW)	6100	-	6250
TAZ-8A clad + Xcoat B (SEW)	6100	-	-
TAZ-8A DS	2200	-	6250[a]
M22	-	500	-
IN 713C	-	500	-
IN 738	200	500	500
IN 162	-	600	-
MAR-M 509	500	500	700
René 80	200	500	500
RBH	300	-	500
NASA VI A	300	600	700
TD-NiCr	200	200	-
MAR-M 302	-	500	-
WI-52	-	500	-
X-40	300	500	-

[a]Two specimens were tested for the same number of cycles.

TABLE 35. - SUMMARY OF CRACK PROPAGATION FOR SERIES G SPECIMENS

CYCLED BETWEEN 2065°F (1129°C) AND 675°F (357°C)

(3 min dwell in each bed)

Edge Radius, in.	Cycles	Crack length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		B1900 + Jocoat (A)								
0.025, 0.040	100	Cracks not observed.								
	300	Cracks starting from both fixture holes approx. 0.200 long but no cracks in test area.								
	700	Top of specimen detached.								
	1200	Severe distortion of remainder of specimen.								
	1700	Specimen lost in bed, not available for inspection.								
		B1900 + Jocoat (B)								
0.025, 0.040	100	Cracks not observed.								
	300	Cracks starting from both fixture holes.								
	800	No cracks in test area but specimen distorted.								
	1300	Crack across center of section not initiating at edges.								
0.025	Distance from bottom: 1.65 in.									
	1300	.370	.380	.375	--	--	--	--	--	--
0.040	1300	Cracks not observed.								
		B1900 DID + Jocoat (Specimen 1)								
0.025, 0.040	700	Cracks not observed.								
	900	Cracks commencing at top fixing hole.								
	1100	Cracks at top fixing hole 0.300 in length.								
	1300	Top of specimen detached.								
0.025	Distance from bottom: 1.92 in.									
	1800	.420	.430	.425	--	--	--	--	--	--
	2300	.550	.560	.550	--	--	--	--	--	--
0.040	2300	Cracks not observed.								

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		IN-100 + Jocoat (Specimen P)								
0.025	Distance from bottom:	2.67 in.								
	25	Cracks not observed								
	50	.282	.312	.297						
	100	.357	.375	.366						
	200	.388	.435	.412						
	300	.434	.450	.442						
0.040	300	Cracks not observed								
		IN-100 + Xcoat A (Specimen 1)								
0.025	Distance from bottom:	2.00 in.			2.60 in.					
	25	Cracks not observed								
	50	.274	.252	.263						
	100	.327	.352	.340	0	0	0			
	200	.438	.426	.432	.409	.373	.391			
0.040	200	Cracks not observed								
		IN-100 DS (Specimen 7)								
0.025	Distance from bottom:	1.30 in.			2.10 in.					
	1100	Cracks not observed								
	1300	.030	.030	.030	.016	.014	.015			
	1500	.050	.048	.049	.025	.023	.024			
	1700	.065	.062	.064	.034	.033	.034			
	1900	.080	.075	.078	.045	.040	.043			
	2400	.085	.080	.083	.050	.045	.048			
0.040	2400	Cracks not observed								

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
IN-100 DS + Jocoat (Specimen 5)										
0.025	Distance from bottom:		1.10 in.				2.25 in.			
	1700	Cracks not observed. Coating started to chip off edge at 900 cycles.								
	2200	.132	.106	.119	.093	.070	.082			
0.040	2200	Cracks not observed								
MAR-M 200 + Jocoat										
0.025	550	Cracks not observed								
0.040	Distance from bottom:		3.40 in.				2.25 in.			
	0	Cracks not observed								
	25	.260	.240	.250						
	50	.380	.415	.398	0	0	0			
	550	Top cracked off			.550	.520	.535			
MAR-M 200 DS										
0.025	Distance from bottom:		1.94 in.				2.86 in.			
	1100	Cracks not observed								
	1300	.030	.035	.033						
	1500	.085	.093	.089	0	0	0			
	1700	.142	.133	.147	.049	.039	.044			
	1900	.142*	.133*	.147*	.050	.045	.048			
	2400	.142	.133	.147						
	*Crack turned at right angles and propagating in both directions. At 1900 cycles the branch cracks were .250 and .080 long. At 2400 cycles the right angle branch cracks were both .400 long.									
0.040	2400	Cracks not observed								

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
		Udimet 700 Wrought, Clad + Xcoat B (SEW)								
0.030	25	Cracks not observed								
	50	Cracks starting from lower fixing hole								
	300	Cracked through fixing hole								
	800	Distortion in test area but no cracks								
	1300	Apparent crack at 1.70 in. from bottom but obscured by cladding								
		NX-188 (Specimen 1)								
0.025	Distance from bottom:			2.00 in			2.27 in.			1.35 in.
	100	.130	.154	.142	.122	.161	.142	.140	.125	.133
	200	.223	.207	.215	.197	.188	.193	.268	.212	.240
	300	.245	.211	.227	.227	.205	.216	.285	.255	.270
	500	.278	.275	.277	.258	.223	.241	.342	.313	.328
0.040	Distance from bottom:			2.00 in.			2.67 in.			1.35 in.
	100	Cracks not observed								
	200	.206	.204	.205	0	0	0	0	0	0
	300	.210	.212	.211	.192	.206	.197	.121	.116	.119
	500	.215	.218	.217	.200	.215	.208	.148	.155	.152
		NX-188 + RT-1A Coat (Specimen 3)								
0.025	Distance from bottom:			2.33 in.			2.84 in.			1.85 in.
	100	Cracks not observed								
	300	.021	.084	.053	0	0	0			
	500	.141	.237	.214	.125	.155	.140			
	700	.310	.332	.321	.215	.206	.211	0	0	0
	1100	.404	.380	.392	.290	.298	.294	.160	.185	.173
0.040	Distance from bottom:			2.30 in.			1.68 in.			
	500	Cracks not observed								
	700	.094	--	.047	0	0	0			
	1100	.129	.136	.133	.103	.137	.120			

TABLE 35 (cont.)

Edge Radius, in.	Cycles	First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
		NX-188 DS (1)								
0.025, 0.040	3500	Cracks not observed								
	4000	Short cracks at fixing holes								
0.025	Distance from bottom:	2.34 in.			2.96 in.			1.61 in.		
	4750	Cracks not observed								
	5500	.145	.181	.163	.144	.209	.177	0	0	0
	6500	.266	.268	.267	.262	.245	.254	.189	.190	.190
0.040	6500	Cracks not observed								
		NX-188 DS + RT-1A Coat (4)								
0.025, 0.040	3600	Coating detaching from both edges								
	6100	Cracks not observed								
		WAZ-20 + Jocoat (Specimen 3)								
0.025	Distance from bottom:	1.83 in.			3.19 in.			2.54 in.		
	0	Cracks not observed								
	25	.381	.397	.389	.293	.347	.320	0	0	0
	50	.467	.420	.444	.356	.382	.369	.327	.368	.348
0.040	50	Cracks not observed								
		WAZ-20 DS + Jocoat (3)								
0.025	Distance from bottom:	2.34 in.								
	900	Small notches appearing in edges								
	1100	Cracks not observed								
	1600	Notches approx. .150 deep, surface roughening very noticeable								
		.317	.488	.403	(apparent extent of crack but may be cracks in oxide coating)					
	3600	Notch depth approx. .300								
0.040	6100	Notches approx. .050 deep.								

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
TAZ-8A										
0.025	Distance from bottom:	1.20 in.			1.88 in.			2.75 in.		
	400	Cracks not observed								
	500	.355	.363	.359	.345	.281	.313			
	600	.392	.395	.394	.380	.359	.370	0	0	0
	700	.395	.404	.400	.411	.376	.394	.395	.410	.403
	900	.414	.435	.425	.465	.392	.429	.400	.415	.408
	1100	.490	.497	.494	.501	.428	.465	.487	.444	.466
0.040	1100	Cracks not observed								
TAZ-8A (SEW)										
0.030	Distance from bottom:	2.70			2.25 in.			1.35 in.		
	1100	Cracks not observed								
	1600	Cracks commencing near fixing hole approx. .121 long								
	2100	Cracks not observed in test section								
	2600	.096	.092	.094	.040	.052	.046	0	0	0
	6100	.185	.195	.190	.198	.210	.204	.195	.205	.200
TAZ-8A Clad + Xcoat B (SEW)										
0.030	500	Cladding commencing to peel off back edge								
	6100	Cracks not observed but may be obscured by peeling cladding. Metallographic examination showed that small cracks were present.								
TAZ-8A DS (Specimen 1)										
0.025	Distance from bottom:	1.27 in.								
	1100	Cracks not observed								
	1300	.115	.096	.106						
	1500	.137	.136	.137						
	1700	.152	.156	.154						
	2200	.194	.201	.198						
0.040	2200	Cracks not observed								

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in. First Crack Front	Back	Avg	Second Crack Front	Back	Avg	Third Crack Front	Back	Avg
		IN-738 (Specimen 2)								
0.025	Distance from bottom:			1.78 in.			2.25 in.			3.00 in.
	100	.261	.271	.266	.279	.288	.284	0	0	0
	200	.309	.335	.322	.311	.307	.309	.287	.276	.282
0.040	Distance from bottom:			1.55 in.						
	100	Cracks not observed								
	200	.022	.020	.021						
		MAR-M 509 (Specimen 9)								
0.025	Distance from bottom:			2.90 in.			2.20 in.			2.50 in.
	200	Cracks not observed								
	300	.104	.137	.121	.053	.089	.071	.048	.076	.062
	400	.249	.220	.235	.133	.155	.144	.106	.152	.129
	500	.278	.308	.293	.160	.175	.168	.140	.175	.163
0.040	Distance from bottom:			2.17 in.						
	100	Cracks not observed								
	200	.052	.102	.077						
	300	.141	.162	.152						
	400	.213	.240	.227						
	500	.280	.282	.281						
		René 80 (Specimen 1)								
0.025	Distance from bottom:			1.50 in.			2.00 in.			2.40 in.
	100	.322	.269	.296	.288	.220	.254	.284	.260	.272
	200	.342	.342	.342	.335	.277	.308	.320	.268	.294
0.040	Distance from bottom:			2.80 in.			1.45 in.			
	100	Cracks not observed								
	200	.096	.052	.074	.082	0	.041			

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
RBH (Specimen 1)										
0.025	Distance from bottom:			2.71 in.			2.14 in.			1.83 in.
	100	.153	.173	.163	.157	.115	.136	.160	.166	.163
	200	.332	.349	.341	.275	.266	.271	.265	.248	.257
	300	.335	.380	.358	.283	.281	.282	.271	.264	.275
0.040	Distance from bottom:			2.25 in.						
	100	Cracks not observed								
	200	.209	.182	.196						
	300	.211	.195	.203						
NASA VI A (Specimen 2)										
0.025	Distance from bottom:			3.35 in.			1.38 in.			
	50	Cracks not observed								
	100	.282	.312	.297	0	0	0			
	200	.345	.330	.338	.338	.349	.345			
	300	.367	.346	.357	.420	.400	.410			
0.040	Distance from bottom:			2.58 in.						
	25	Cracks not observed								
	50	.255	.236	.246						
	100	.329	.333	.331						
	200	.369	.390	.380						
	300	.404	.392	.398						

TABLE 35 (cont.)

Edge Radius, in.	Cycles	Crack length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
				TD-NiCr						
0.025	Distance from bottom:			2.70 in.			2.10 in.			1.56 in.
	25	.270	.261	.266	.225	.197	.211	.113	.142	.128
	50	.372	.363	.368	.348	.355	.352	.300	.291	.296
	100	.395	.378	.387	.385	.385	.385	.355	.345	.350
	200	.403	.410	.407	.423	.437	.430	.390	.363	.377
0.040	Distance from bottom:			2.75 in.			2.30 in.			1.55 in.
	25	Cracks not observed								
	50	.112	.150	.131	.052	0	.026	0	0	0
	100	.220	.214	.217	.121	.121	.121	.045	.065	.055
	200	.270	.252	.261	.192	.192	.192	.150	.153	.152
				X-40						
0.025	Distance from bottom:			1.62 in.			2.64 in.			1.00 in.
	100	Cracks not observed								
	200	.175	.190	.183	.142	.168	.155	0	0	0
	300	.298	.277	.288	.276	.246	.261	.139	.137	.138
0.040	Distance from bottom:			2.60 in.			2.33 in.			1.63 in.
	100	Cracks not observed								
	200	.100	.090	.095	.042	.020	.031	.040	.022	.031
	300	.183	.200	.192	.047	.091	.069	.051	.040	.046

TABLE 36. - SUMMARY CRACK PROPAGATION FOR SERIES H SPECIMENS

CYCLED BETWEEN 1915°F (1046°C) AND 525°F (274°C)

(3 min dwell in each bed)

Edge Radius, in.	Cycles	Crack length in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
				B1900						
0.025	Distance from bottom:			1.43 in.			2.30 in.			2.63 in.
	200	No cracks observed								
	300	.244	.219	.232	0	0	0	0	0	0
	400	.301	.247	.274	.237	.217	.227	.178	.176	.177
	500	.398	.287	.298	.289	.278	.284	.226	.272	.252
	600	.336	.310	.323	.309	.282	.296	.260	.285	.273
0.040	600	No cracks observed								
				IN-100						
0.025	Distance from bottom:			2.60 in.			1.80 in.			1.30 in.
	50	No cracks observed								
	100	.300	.297	.299	.257	.247	.253	.181	.228	.205
	150	.302	.342	.322	.324	.333	.329	.219	.249	.234
	200	.360	.385	.373	.374	.350	.362	.225	.263	.244
0.040	Distance from bottom:			1.48 in.						
	100	No cracks observed								
	150	.095	.127	.111						
	200	.101	.132	.118						
				IN-100 + Jocoat (By TRW)						
0.025	Distance from bottom:			1.05 in.			2.10 in.			2.48 in.
	300	No cracks observed								
	400	.372	.343	.358	.265	.256	.261	.279	.232	.256
	500	.405	.381	.393	.287	.285	.286	.335	.238	.287

TABLE 36 (cont.)

Edge Radius, in.	Cycles	Crack length, in. — First Crack, Front	First Crack, Back	First Crack, Avg	Second Crack, Front	Second Crack, Back	Second Crack, Avg	Third Crack, Front	Third Crack, Back	Third Crack, Avg
0.040	Distance from bottom:			2.22 in.						
	300	No cracks observed								
	400	.258	.288	.273						
	500	.272	.290	.281						
		IN-100 + Xcoat A								
0.025	Distance from bottom:			2.28 in.			1.35 in.			
	50	.278	.300	.289	.284	.235	.260			
	100	.308	.311	.310	.345	.310	.328			
	150	.336	.339	.338	.347	.328	.338			
	200	.358	.358	.358	.358	.330	.344			
	300	.381	.380	.381	.365	.370	.368			
	400	.418	.409	.414	.371	.428	.400			
	500	.422	.415	.419	.397	.441	.419			
0.040	500	No cracks observed								
		MAR-M 200								
0.025	Distance from bottom:			1.33 in.			1.91 in.			1.72 in.
	50	.255	.258	.257	.161	.162	.162	.090	.105	.098
	100	.354	.341	.248	.308	.332	.320	.092	.113	.103
	150	.363	.343	.253	.340	.360	.350	.097	.113	.105
	200	.363	.352	.358	.365	.361	.363	.090	.113	.106
0.040	Distance from bottom:			2.70 in.			1.14 in.			
	50	No cracks observed								
	100	.266	.240	.253	0	0	0			
	150	.320	.278	.299	.240	.240	.240			
	200	.324	.297	.311	.240	.289	.265			

TABLE 36 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
		Udimet 700 (Wrought)								
0.025	Distance from bottom:			1.32 in.			2.20 in.			2.75 in.
	100	Cracks not observed								
	150	.298	.319	.309	.108	.074	.091	0	0	0
	200	.327	.365	.346	.218	.278	.248	.305	.312	.309
0.040	Distance from bottom:			2.00 in.						
	150	Cracks not observed								
	200	.235	.210	.233						
		Udimet 700 (Cast)								
0.025	Distance from bottom:			1.34 in.			2.30 in.			2.75 in.
	100	Cracks not observed								
	150	.125	.140	.133	.047	.042	.045	0	0	0
	200	.227	.247	.237	.199	.185	.192	.182	.203	.193
	300	.285	.299	.292	.235	.233	.234	.297	.268	.283
	400	.312	.315	.314	.280	.285	.283	.330	.313	.322
	500	.364	.325	.345	.282	.287	.285	.355	.329	.342
0.040	Distance from bottom:			2.33 in.			1.45 in.			
	150	Cracks not observed								
	200	.075	.065	.070						
	300	.086	.076	.081						
	400	.115	.118	.117	0	0	0			
	500	.136	.127	.132	0	.085	.043			
		TAZ-8A								
0.025, 0.040	600	No cracks observed								

TABLE 36 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
				M22						
0.025	Distance from bottom:			2.50 in.			2.14 in.			1.30 in.
	50	.023	.050	.037	0	0	0			
	100	.067	.127	.097	.030	.153	.092			
	150	.160	.134	.147	.185	.227	.206	0	0	0
	200	.177	.141	.159	.201	.235	.218	.020	0	.010
	300	.270	.245	.258	.285	.329	.307	.287	.188	.238
	400	.330	.378	.354	.291	.340	.314	.337	.316	.327
	500	.375	.400	.388	.320	.345	.333	.355	.351	.353
0.040	Distance from bottom:			2.70 in.						
	300	No cracks observed								
	400	.019	.015	.017						
	500	.038	.027	.033						
				IN-713C						
0.025	Distance from bottom:			2.45 in.			1.64 in.			1.14 in.
	100	No cracks observed								
	150	.092	.051	.072	.050	.040	.045			
	200	.157	.162	.160	.200	.210	.205	0	0	0
	300	.352	.320	.346	.348	.339	.344	.274	.270	.272
	400	.365	.371	.368	.359	.341	.350	.290	.305	.298
	500	.377	.375	.376	.372	.355	.364	.312	.332	.322
0.040	Distance from bottom:			2.10 in.						
	400	No cracks observed								
	500	.048	.026	.037						

TABLE 36 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
				IN-738						
0.025	Distance from bottom:			2.02 in.			1.20 in.			2.82 in.
	100	No cracks observed								
	150	.226	.217	.222	0	0	0			
	200	.276	.256	.266	.157	.187	.172	0	0	0
	300	.311	.341	.326	.291	.310	.301	.186	.167	.177
	400	.354	.359	.357	.340	.341	.341	.239	.183	.211
	500	.360	.365	.363	.392	.357	.375	.252	.264	.258
0.040	Distance from bottom:			2.64 in.						
	150	No cracks observed								
	200	.132	.143	.138						
	300	.229	.222	.226						
	400	.264	.242	.253						
	500	.285	.273	.279						
				IN-162						
0.025	Distance from bottom:			1.20 in.			2.87 in.			2.33 in.
	300	No cracks observed								
	400	.230	.229	.230	0	0	0	0	0	0
	500	.244	.238	.241	.130	.145	.138	.127	.142	.135
	600	.340	.321	.206	.195	.206	.201	.273	.248	.261
0.040	600	No cracks observed								
				MAR-M 509						
0.025	Distance from bottom:			1.83 in.			1.47 in.			2.30 in.
	100	No cracks observed								
	150	.055	.050	.053						
	200	.097	.067	.082	0	0	0	0	0	0
	300	.123	.110	.117	.123	.110	.117	.086	.090	.088
	400	.168	.154	.162	.159	.174	.167	.135	.105	.120
	500	.189	.190	.190	.194	.175	.185	.157	.167	.162

Table 36 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
0.040	Distance from bottom:			1.45 in.			2.58 in.			1.77 in.
	300	No cracks observed								
	400	.167	.033	.100	.090	.072	.081	.071	.063	.067
	500	.178	.129	.154	.143	.080	.112	.087	.077	.082
					René 80					
0.025	Distance from bottom:			2.08 in.			1.30 in.			2.25 in.
	100	No cracks observed								
	150	.120	.093	.107	0	0	0			
	200	.140	.153	.147	.098	0	.049	0	0	0
	300	.214	.207	.211	.167	.115	.141	.064	.079	.072
	400	.275	.226	.251	.205	.192	.199	.090	.119	.105
	500	.283	.230	.257	.216	.194	.205	.120	.135	.128
0.040	500	One sided cracks only that do not propagate through the section								
					NASA VI A					
0.025	Distance from bottom:			1.13 in.			1.78 in.			2.52 in.
	200	No cracks observed								
	300	.305	.317	.311	.305	.287	.296	.163	.148	.156
	400	.348	.330	.339	.327	.322	.325	.215	.195	.205
	500	.351	.350	.351	.342	.328	.335	.243	.244	.244
	600	.363	.361	.362	.345	.341	.343	.288	.272	.280
0.040	600	No cracks observed								
					TD-NiCr					
0.025	Distance from bottom:			2.67 in.			1.80 in.			1.45 in.
	50	.130	.108	.119	.039	0	.020	0	0	0
	100	.336	.333	.335	.370	.368	.369	.242	.234	.238
	150	.451	.439	.445	.444	.453	.449	.469	.465	.467
	200	.465	.440	.453	.460	.465	.463	.485	.465	.475

TABLE 36 (cont.)

Edge Radius, in.	Cycles	First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
0.040	Distance from bottom:			2.60 in.						
	50	No cracks observed								
	100	.057	.053	.055						
	150	.098	.098	.098						
	200	.131	.147	.139						
				MAR-M 302						
0.025	Distance from bottom:			1.30 in.			1.30 in.			2.44 in.
	200	No cracks observed								
	300	.065	.073	.069	.061	.068	.065	.060	.063	.062
	400	.114	.137	.126	.158	.147	.153	.113	.126	.120
	500	.162	.169	.166	.200	.199	.200	.168	.148	.158
0.040	Distance from bottom:			2.56 in.			3.02 in.			1.86 in.
	200	No cracks observed								
	300	.134	.120	.127	.110	.101	.106	.138	0	.069
	400	.173	.172	.173	.140	.144	.142	.191	.142	.167
	500	.220	.216	.218	.214	.191	.203	.225	.180	.203
				WI-52						
0.025	Distance from bottom:			1.38 in.			2.20 in.			2.68 in.
	100	No cracks observed								
	150	.104	.088	.096	0	0	0	0	0	0
	200	.165	.166	.166	.133	.117	.125	.082	.060	.071
	300	.214	.222	.214	.207	.197	.202	.141	.124	.133
	400	.250	.255	.253	.253	.237	.245	.165	.153	.149
	500	.274	.265	.270	.270	.282	.276	.185	.161	.173
0.040	Distance from bottom:			1.65 in.			1.95 in.			2.17 in.
	200	No cracks observed								
	300	.128	.065	.097	.071	.068	.070	.116	.044	.080
	400	.150	.117	.134	.125	.108	.117	.122	.075	.098
	500	.165	.125	.145	.130	.115	.123	.132	.107	.120

TABLE 36 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
				X-40						
0.025	Distance from bottom:			1.00 in.			1.48 in.			2.07 in.
	150	No cracks observed								
	200	.065	.053	.059	.031	0	.016	0	0	0
	300	.117	.116	.117	.041	.030	.036	.125	.077	.101
	400	.200	.203	.202	.110	.112	.111	.191	.176	.184
	500	.251	.253	.252	.138	.115	.127	.264	.249	.257
0.040	Distance from bottom:			1.58 in.						
	200	No cracks observed								
	300	.060	.047	.054						
	400	.085	.078	.082						
	500	.090	.102	.096						

TABLE 37. - SUMMARY OF CRACK PROPAGATION FOR SERIES I SPECIMENS

CYCLED BETWEEN 1990°F (1088°C) AND 600°F (316°C)

(3 min dwell in each bed)

Edge Radius, in.	Cycles	Crack Length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		B1900 DID + Jocoat (Specimen 4)								
0.025	Distance from bottom:			2.15 in.			2.55 in.			
	470	Cracks not observed								
	700	.297	.317	.307	0	0	0			
	900	.367	.343	.355	.286	.280	.283			
	1200	.404	.385	.395	.357	.342	.350			
0.040	1200	Cracks not observed								
		B1900 DID + Jocoat (Specimen 2)								
0.025	Distance from bottom:			1.40 in.			2.40 in.			
	2000	Cracks not observed								
	2750	.366	.380	.373	.273	.308	.291			
	3250	.412	.422	.417	.381	.402	.392			
0.040	3250	Cracks not observed								
		IN-100 + Xcoat A								
0.025	Distance from bottom:			1.02 in.			1.80 in.			
	0	Cracks not observed								
	50	.335	.310		0	0	0			
	100	.372	.390		.280	.254	.267			
	175	.380	.400		.330	.325	.328			
	300	.382	.410		.390	.360	.375			
	470	.465	.416		.413	.370	.392			
0.040	470	Cracks not observed								

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
		MAR-M 200 + Jocoat								
0.025	Distance from bottom:			1.33 in.			2.30 in.			
	0	Cracks not observed								
	50	.360	.380	.370						
	100	.415	.398	.407						
	175	.420	.415	.418	0	0	0			
	300	.422	.420	.421	.365	.380	.373			
	470	.452	.549	.500	.452	.500	.476			
0.040	470	Cracks not observed								
		MAR-M 200 DS (Specimen 12)								
0.025	Distance from bottom:			2.92 in.			1.71 in.			2.50 in.
	1500	Cracks not observed								
	2000	.023	.025	.024	.021	.010	.016			
	2750	.060	.110	.085	.055	.050	.053	.063	.048	.056
	3250	.092	.119	.106	.116	.093	.105	.109	.103	.106
	4000	.143	.135	.139	.168	.155	.162	.147	.134	.141
0.040	4000	Cracks not observed								
		NX-188 (Specimen 2)								
0.025	Distance from bottom:			1.42 in.			2.50 in.			2.12 in.
	175	Cracks not observed								
	300	.225	.207	.216	.185	.171	.178	.051	.083	.067
	470	.312	.302	.307	.295	.288	.292	.155	.150	.153
	700	.356	.378	.367	.343	.315	.329	.207	.205	.206
0.040	Distance from bottom:			2.70 in.			1.38 in.			1.60 in.
	175	Cracks not observed								
	300	.058	.072	.065	.045	.070	.058	0	0	0
	470	.088	.121	.106	.092	.084	.088	.071	.030	.051
	700	.133	.174	.155	.130	.097	.114	.131	.059	.095

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		NX-188 (Specimen 4)								
0.025	Distance from bottom:	2.73 in.			1.54 in.			1.94 in.		
	0	Cracks not observed								
	200	.170	.227	.199	.182	.178	.180	.095	.080	.088
	500	.340	.316	.328	.280	.292	.286	.106	.183	.051
0.040	Distance from bottom:	2.20 in.								
	200	Cracks not observed								
	500	.055	.013	.034						
		NX-188 + RT-1A Coat (Specimen 1)								
0.025	Distance from bottom:	2.86 in.			2.40 in.			1.63 in.		
	200	Cracks not observed								
	400	.119	.120	.120	.057	.025	.041	0	0	0
	700	.289	.280	.285	.128	.102	.115	.220	.241	.231
0.040	700	Cracks not observed								
		NX-188 + RT-1A Coat (Specimen 2)								
0.025	Distance from bottom:	1.12 in.			1.68 in.					
	700	Cracks not observed								
	900	.275	.268	.272	.246	.254	.250			
	1200	.330	.334	.332	.343	.335	.339			
0.040	1200	Cracks not observed								
		NX-188 DS (Specimen 2)								
0.025	Distance from bottom:	2.68 in.			1.73 in.					
	4000	Cracks not observed, specimens covered with green oxide and have obviously lost material								
	4700	.088	.103	.096	.026	.052	.039			
	5500	.121	.106	.114	.106	.095	.101			
	6250	.220	.156	.188	.115	.100	.108			
0.040	6250	Cracks not observed								

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		NX-188 DS (Specimen 4)								
0.025	Distance from bottom:	1.73 in.			2.76 in.			2.34 in.		
	4000	Cracks not observed, specimens covered with green oxide and have obviously lost material								
	4700	.059	.045	.052	.033	.030	.032	.027	.025	.026
	5500	.067	.052	.060	.080	.080	.080	.075	.074	.075
	6250	.075	.060	.068	.085	.090	.088	.080	.084	.082
0.040	Distance from bottom:	1.93 in.								
	4000	Cracks not observed, specimens covered with green oxide and have obviously lost material								
	4700	.009	.014	.012						
	5500	.032	.040	.036						
	6250	.045	.055	.050						
		NX-188 DS + RT-1A Coat (Specimen 1)								
0.025	Distance from bottom:	2.18 in.			2.85 in.					
	4000	Horizontal lines developing in coating across center of test piece								
	4700	Coating starting to chip off edges of test piece								
	5500	.157	.225	.191	0	0	0			
	6250	.251	.301	.276	.128	.201	.165			
0.040	6250	Cracks not observed								
		NX-188 DS + RT-1A Coat (Specimen 2)								
0.025	Distance from bottom:	2.82 in.								
	4000	Horizontal lines developing in coating across center of test piece								
	4700	Coating starting to chip off edges of test piece								
	5500	.121	.087	.104						
	6250	.187	.125	.156						
0.040	6250	Cracks not observed								

TABLE 37 (cont.)

Edge Radius, in.	Cycles	First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
					Crack Length, in.					
WAZ-20 + Jocoat (Specimen 1)										
0.025	Distance from bottom:	2.92 in.			2.03 in.			0.98 in.		
	100	Cracks not observed								
	175	.320	.290	.305						
	300	.390	.380	.385	0	0	0			
	470	.392	.395	.394	.375	.355	.365	0	0	0
	700	.395	.405	.400	.430	.409	.420	.385	.385	.385
0.040	700	Cracks not observed								
WAZ-20 + Jocoat (Specimen 2)										
0.025	Distance from bottom:	3.36 in.			2.37 in.			1.62 in.		
	0	Cracks not observed								
	200	.306	.342	.324	.295	.315	.305	.312	.284	.298
	400	.372	.368	.370	.386	.332	.359	.352	.302	.327
	700	.373	.387	.380	.392	.496	.444	.380	.389	.385
0.040	700	Cracks not observed								
WAZ-20 DS + Jocoat (Specimen 1)										
0.025	Distance from bottom:	2.50 in.			1.90 in.			2.20 in.		
	2000	Surface started to roughen from the commencement of cycling within the formation of a rough scale. Some indication of cracks at 1.90 and 2.50 in. was observed, but accurate measurement could not be attempted								
	3250	Coating dropping off in patches								
	4700	Edges starting to crumble and erode with inlets 0.30 in. deep								
	5500	.280	.250	.265	.190	.160	.175	.120	.130	.125
0.040	5500	Cracks not observed								

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
		WAZ-20 DS + Jocoat (Specimen 2)								
0.025	Distance from bottom:	2.80 in.			3.00 in.			2.10 in.		
	2000	Surface started to roughen from the commencement of cycling with the formation of a rough scale. Some indication of cracks at 2.80 and 3.00 in. was observed, but accurate measurement could not be attempted.								
	3250	Coating dropping off in patches								
	4700	Edges starting to crumble and erode with inlets 0.040 in. deep								
	5500	.326	.320	.323	.218	.260	.239	.176	.150	.163
0.040	5500	Cracks not observed								
		TAZ-8A								
0.025	Distance from bottom:	1.28 in.			2.04 in.			2.57 in.		
	700	Cracks not observed								
	900	.308	.302	.305	.274	.272	.273	.268	.238	.253
	1200	.391	.409	.400	.326	.346	.336	.355	.385	.370
0.040	1200	Cracks not observed								

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in. First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
		TAZ-8A Single Wedge								
0.025	Distance from bottom:	1.83 in.			2.28 in.			3.00 in.		
	700	Cracks not observed								
	900	.085	.058	.070	These values are surface cracks probably in the surface scale on this specimen. The cracks in the metal have not propagated to the same extent as shown by later observations.					
	1200	.142	.075	.110						
	1500	.150	.090	.120						
	2000, 2750, 3250	Cracks masked by scales on surface								
	4000	.040	.085	.063	.060	.066	.063	.062	.048	.055
	4700	.045	.095	.070	.078	.085	.082	.096	.054	.075
	5500	.047	.105	.076	.102	.103	.103	.104	.100	.102
	6250	.090	.125	.108	.140	.132	.136	.135	.120	.128
		TAZ-8A DS (Specimen 2)								
0.025	Distance from bottom:	1.17 in.			0.95 in.			2.00 in.		
	4000	Cracks not observed								
	4700	.057	.055	.056	0	0	0			
	5500	.067	.057	.062	.069	.054	.062	0	0	0
	6250	.103	.095	.099	.076	.065	.071	.027	.030	.029
0.040	6250	Cracks not observed								
		TAZ-8A DS (Specimen 4)								
0.025	Distance from bottom:	1.98 in.			0.80 in.					
	4000	Cracks not observed								
	4700	.070	.075	.073						
	5500	.072	.103	.088	0	0	0			
	6250	.142	.138	.140	.120	.116	.118			

TABLE 37 (cont.)

Edge Radius, in.	Cycles	First Crack Front	First Crack Back	First Crack Avg	Second Crack Front	Second Crack Back	Second Crack Avg	Third Crack Front	Third Crack Back	Third Crack Avg
0.040	Distance from bottom:			2.78 in.			2.38 in.			
	3250	Cracks not observed								
	4000	.220	.230	.225	0	0	0			
	4700	.246	.287	.267	.118	.070	.094			
	5500	.360	.340	.350	.208	.146	.177			
	6250	.370	.355	.363	.220	.208	.214			
				IN-738						
0.025	Distance from bottom:			1.96 in.			2.64 in.			0.74 in.
	0	Cracks not observed								
	200	.362	.320	.341	.272	.306	.289	.275	.255	.265
	500	.370	.406	.388	.364	.404	.384	.372	.367	.370
0.040	500	Cracks not observed								
				MAR-M 509						
0.025	Distance from bottom:			0.60 in.			1.99 in.			2.80 in.
	175	Cracks not observed								
	300	.103	.099	.101	.114	.081	.096	.105	.095	.100
	470	.184	.186	.185	.162	.122	.142	.158	.160	.159
	700	.245	.247	.246	.225	.136	.181	.200	.202	.201
0.040	Distance from bottom:			1.63 in.			2.08 in.			
	470	Cracks not observed								
	700	.115	.116	.116	.110	.085	.098			
				René 80						
0.025	Distance from bottom:			2.12 in.			1.22 in.			3.02 in.
	0	Cracks not observed								
	200	.230	.244	.237	.210	.218	.214	.044	.120	.082
	500	.267	.280	.274	.252	.255	.254	.240	.254	.247

TABLE 37 (cont.)

Edge Radius, in.	Cycles	Crack Length, in.								
		First Crack			Second Crack			Third Crack		
		Front	Back	Avg	Front	Back	Avg	Front	Back	Avg
0.040	Distance from bottom:			2.14 in.			1.54 in.			2.80 in.
	0	Cracks not observed								
	200	.115	.111	.113	.111	.097	.104	0	0	0
	500	.137	.124	.131	.115	.098	.107	.230	.214	.222
				RBH						
0.025	Distance from bottom:			2.28 in.			0.80 in.			1.95 in.
	0	Cracks not observed								
	200	.180	.174	.177	.140	.142	.141	.115	.117	.116
	500	.230	.227	.229	.252	.287	.271	.253	.256	.255
0.040	Distance from bottom:			2.58 in.			1.60 in.			1.02 in.
	200	Cracks not observed								
	500	.216	.211	.214	.185	.194	.190	.105	.173	.139
				NASA VI A						
0.025	Distance from bottom:			2.07 in.			0.69 in.			2.88 in.
	100	Cracks not observed								
	175	.320	.290	.305	0	0	0			
	300	.360	.340	.350	.325	.330	.328	0	0	0
	470	.394	.344	.369	.382	.354	.368	.320	.315	.318
	700	.402	.350	.376	.407	.370	.389	.375	.375	.375
0.040	Distance from bottom:			1.32 in.						
	300	Cracks not observed								
	470	.150	.120	.135						
	700	.300	.308	.304						

TABLE 38. - THERMAL CYCLES REQUIRED TO INITIATE

THE FIRST CRACK IN EACH EDGE

Alloy and Condition	2065/675°F (1129/357°C) .025 edge	2065/675°F (1129/357°C) .040 edge	1915/525°F (1046/274°C) .025 edge	1915/525°F (1046/274°C) .040 edge	1990/600°F (1088/316°C) .025 edge	1990/600°F (1088/316°C) .040 edge
B1900	-	-	250	>600	400[a]	800[a]
B1900 + Jocoat	>1200 (1050)	>1200 (>1300)	-	-	1190[a]	1700[a]
B1900 DID + Jocoat	1550	>2300	-	-	2375 (585)	>3250 (>1200)
IN-100	-	-	75	125	38[a]	150[a]
IN-100 + Jocoat	37	>300	350	350	600[a]	400[a]
IN-100 + Xcoat A	37	>200	25	>500	25	>470
IN-100 DS	1200	>2400	-	-	2400[a]	>5000[a]
IN-100 DS + Jocoat	1950	>2200	-	-	2400[a]	2400[a]
MAR-M 200	-	-	25	75	13[a]	38[a]
MAR-M 200 + Jocoat	>550	13	-	-	25	>470
MAR-M 200 DS	1200	>2400		-	1750 4700[a]	>4000 >5000[a]
Udimet 700 wrought	-	-	125	175	13[a]	75[a]
Udimet 700 cast	-	-	125	175	75[a]	150[a]
Udimet 700 wrought, clad + Xcoat B (SEW)	1300	-	-	-		
NX-188	50	150	-	-	238 (100)	238 (350)
NX-188 + RT-1A coat	200	600	-	-	800 (300)	>1200 (>700)
NX-188 DS	5125	>6500	-	-	4350 (4350)	>6250 (4350)
NX-188 DS + RT-1A coat	>6100	6100	-	-	5100 (5100)	>6250 (>6250)
WAZ-20 + Jocoat	13	>50	-	-	138 (100)	>700 (>700)
WAZ-20 DS + Jocoat	1350	5600	-	-	1750 (1750)	>5500 (>5500)
TAZ-8A	450	>1100	>600	>600	800 600[a]	>1200 4500[a]
TAZ-8A (SEW)	2350	-	-	-	800	-
TAZ-8A clad + Xcoat B (SEW)	>6100	-	-	-	-	-
TAZ-8A DS	1200	>2200	-	-	4350 (4350)	>6250 (3625)
M22	-	-	25	350	13[a]	75[a]
IN 713C	-	-	125	450	250[a]	600[a]
IN 738	50	150	125	175	100	>500
IN 162	-	-	350	>600	400[a]	600[a]
MAR-M 509	250	150	125	350	238	585
René 80	50	150	125	>500	100	100
RBH	50	150	-	-	100	350
NASA VI A	75	38	250	600	138	385
TD-NiCr	13	38	25	75	250[a]	>1000[a]
MAR-M 302	-	-	250	250	75[a]	250[a]
WI-52	-	-	125	250	75[a]	400[a]
X-40	150	150	175	250	600[a]	600[a]

( ) indicates duplicate specimen

[a] From CR 72738

TABLE 39. - WEIGHT CHANGE OF SERIES G SPECIMENS

2065/675°F (1129/357°C) cycle, 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Original Weight, g	Weight Change After Given Cycles, % 25	50	100	200	300	400	500	600	700	900	1100
B1900 + Jocoat	A	111.808	+0.04	+0.045	+0.04	-	+0.05						
B1900 + Jocoat	B	111.250	-	-	+0.03	+0.03	+0.03						
B1900 DID + Jocoat	1	115.870	0	0	+0.01	+0.01	-	+0.02	+0.02	+0.01	0	-0.03	-0.08
IN-100 + Jocoat	P	111.420	+0.01	+0.01	-0.01	-0.08							
IN-100 + Xcoat A	1	112.250	+0.01	0	+0.01	+0.02							
IN-100 DS	7	110.680	-0.10	-0.45	-0.95	-1.95	-	-4.22	-5.70	-7.50	-8.63	-10.76	-12.92
IN-100 DS + Jocoat	5	110.680	-	-	-0.01	0.06	-0.17	-0.40	-0.55	-	-0.86	-1.22	-
MAR-M 200 + Jocoat	2	122.037	+0.04	+0.05									
MAR-M 200 DS	3	122.260	+0.06	+0.05	+0.02	-0.15	-	-1.03	-1.94	-2.69	-3.41	-4.22	-5.28
Udimet 700 wrought, clad + Xcoat B (SEW)	U3	114.640	+0.01	+0.01	+0.01	-	+0.02						
NX-188	1	113.780	-	-	-0.05	-0.16	-0.31	-	-0.62				
NX-188 + RT-1A coat	3	115.597	+0.013	+0.016	+0.02	-	+0.03	-	-	-	-	-	+0.06
NX-188 DS	1	124.720	-	-	-0.08	-0.24	-0.41	-	-0.79	-	-1.22	-	-
NX-188 DS + RT-1A coat	4	124.239	+0.01	+0.02	+0.02	-	+0.03	-	-	-	-	-	+0.01
WAZ-20 + Jocoat	3	134.861	+0.10	+0.12									
WAZ-20 DS + Jocoat	3	135.398	+0.14	+0.18	+0.23	-	+0.44	-	-	-	-	-	-0.12
TAZ-8A		122.470	+0.02	+0.03	+0.03	+0.03	-	+0.04	+0.04	+0.04	+0.04	+0.04	+0.02
TAZ-8A (SEW)		115.318	+0.02	+0.02	+0.02	-	+0.02	-	-	-	-	-	-0.20
TAZ-8A, clad + Xcoat B (SEW)	R4	119.237	+0.01	+0.01	+0.01	-	+0.01	-	-	-	-	-	+0.02
TAZ-8A DS	1	131.450	-	-	+0.04	+0.04	+0.03	+0.01	-0.01	-	-0.07	-0.26	-
IN-738	2	119.670	-	-	+0.07	+0.07							
MAR-M 509	9	125.830	+0.03	+0.02	+0.02	+0.01	-	+0.03	+0.07	+0.03			
René 80	1	118.940	-	-	+0.06	-0.08							
RBH	1	128.260	-	-	+0.02	+0.04	+0.06						
NASA VI A	2	126.170	+0.04	+0.04	+0.05	+0.07							
TD-NiCr		122.900	0	0	0	0							
X-40		121.320	+0.01	0	0	-0.01	-	-0.01					

Continued Cycles

Alloy and Condition	Spec. Ident.	1500	1600	1700	1900	2000	2100	2200	2400	2500	2600	2900	3000
IN-100 DS	7	-	-	-	-22.06	-	-	-	-29.50	-	-	-37.15	-
IN-100 DS + Jocoat	5	-	-	-2.84	-	-	-	-5.08					
MAR-M 200 DS	3	-	-	-	-9.83	-	-	-	-14.26				
NX-188 + RT-1A coat	3		+0.93	-	-	-	-	-	-	-	-	-	-
NX-188 DS	1	-3.00	-	-	-	-3.93	-	-	-	-4.69	-	-	-5.55
NX-188 DS + RT-1A coat	4	-	-0.021	-	-	-	-0.061	-	-	-	-0.20	-	-
WAZ-20 DS + Jocoat	3	-	-1.61	-	-	-	-5.86	-	-	-	-8.37	-	-
TAZ-8A (SEW)		-	-0.66	-	-	-	-1.20	-	-	-	-1.84	-	-
TAZ-8A clad + Xcoat B (SEW)	R4	-	-0.09	-	-	-	-0.17						
TAZ-8A DS	1	-	-	-1.20									

Continued Cycles

Alloy and Condition	Spec. Ident.	3100	3400	3500	3600	3900	4000	4350	4750	5100	5500	6100	6500
IN-100 DS	7	-	-42.92	-	-	-51.49	-	-	-	-	-	-	-
NX-188 DS	1	-	-	-6.09	-	-	-7.10	-	-8.11	-	-9.00	-	-10.05
NX-188 DS + RT-1A coat	4	-0.39	-	-	-0.56	-	-	-0.82	-	-1.18	-	-2.26	-
WAZ-20 DS + Jocoat	3	-10.85	-	-	-12.50	-	-	-14.97	-	-16.59	-	-20.04	-
TAZ-8A (SEW)		-2.55	-	-	-3.13	-	-	-4.25	-	-5.62	-	-	-

TABLE 40. - WEIGHT CHANGES IN SERIES H SPECIMENS

1915/525°F (1046/274°C) cycle, 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Original Weight, g	Weight Change after Given Cycles, %		
			50	200	500
B1900		111.61	+0.02	+0.02	+0.03
IN 100		111.79	+0.05	-0.22	-
IN 100 + Jocoat	T	111.04	+0.05	+0.03	-0.08
IN 100 + Xcoat A	2	112.54	+0.02	-0.01	-0.15
MAR-M 200		121.40	+0.04	+0.05	-
Udimet 700 wrought		114.32	+0.02	+0.04	-
Udimet 700 cast		111.12	+0.03	+0.04	-0.12
TAZ-8A		122.28	+0.02	+0.02	+0.02
M22		120.37	+0.02	+0.01	+0.01
IN 713C		112.77	+0.01	0	-0.02
IN 738	1	118.74	+0.03	+0.05	+0.04
IN 162		110.82	+0.01	+0.01	+0.01
MAR-M 509	11	127.64	+0.04	+0.04	+0.05
René 80	2	125.40	+0.07	+0.08	-0.28
NASA VI A	9	125.97	+0.04	+0.04	+0.04
TD-NiCr		123.12	0	-0.01	-
MAR-M 302		128.49	+0.02	+0.01	-0.03
WI-52		126.43	+0.01	+0.02	-0.21
X-40		123.75	0	0	-0.01

TABLE 41. - WEIGHT CHANGES IN SERIES I SPECIMENS

1990/600°F (1088/315°C) cycle, 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Original Weight, g	Weight Change After Given Cycles, % 50	200	300	470	500	700	1200	2000	3250	4000	5500
B1900 DID + Jocoat	2	117.620	+0.005	-	+0.013	-	-	+0.016	-0.035	-0.16	-0.54		
B1900 DID + Jocoat	4	118.272	+0.004	-	+0.014	-	-	+0.016	+0.017				
IN-100 + Xcoat A		112.191	+0.012	-	+0.021	+0.026							
MAR-M 200 + Jocoat	1	121.235	+0.031	-	+0.043	+0.040							
MAR-M 200 DS	12	121.120	-0.024	-	-0.045	-	-	-0.45	-1.58	-4.65	-8.60	-11.51	
NX-188	2	113.934	-0.046	-	-0.24	-	-	-0.74					
NX-188	4	111.755	-	-	-	-	+0.22						
NX-188 + RT-1A coat	1	116.551	-	-0.026	-	-	-	-0.10					
NX-188 + RT-1A coat	2	116.911	-0.013	-	-0.061	-	-	-0.15	-0.25				
NX-188 DS	2	125.882	-0.019	-	-0.22	-	-	-0.93	-1.90	-3.18	-5.06	-5.94	-8.11
NX-188 DS	4	126.042	-0.043	-	-0.25	-	-	-0.88	-1.60	-2.68	-4.38	-5.09	-7.25
NX-188 DS + RT-1A coat	1	127.165	-0.006	-	-0.064	-	-	-0.15	-0.22	-0.30	-0.38	-0.41	-0.57
NX-188 DS + RT-1A coat	2	128.034	-0.010	-	-0.051	-	-	-0.13	-0.20	-0.27	-0.40	-0.42	-0.62
WAZ-20 + Jocoat	1	132.437	+0.071	-	+0.094	-	-	+0.069					
WAZ-20 + Jocoat	2	133.390	-	+0.13	-	-	-	+0.15					
WAZ-20 DS + Jocoat	1	136.172	+0.11	-	+0.18	-	-	+0.31	+0.30	-0.017	-1.64	-2.57	-4.94
WAZ-20 DS + Jocoat	2	136.209	+0.11	-	+0.18	-	-	+0.29	+0.31	+0.10	-1.58	-2.47	-4.91
TAZ-8A		121.073	+0.010	-	+0.022	-	-	-0.023	-0.023				
TAZ-8A (SEW)		115.304	+0.028	-	+0.029	-	-	-0.039	-0.23	-0.80	-2.40	-3.21	-5.53
TAZ-8A DS	2	130.782	+0.017	-	+0.021	-	-	+0.005	+0.044	-0.36	-1.17	-1.83	-3.38
TAZ-8A DS	4	130.281	+0.021	-	+0.024	-	-	+0.017	-0.016	-0.22	-0.98	-1.49	-3.06
IN-738	3	118.983	-	-	-	-	+0.035						
MAR-M 509	15	127.799	+0.013	-	+0.007	-	-	+0.004					
René 80	3	117.842	-	-	-	-	-0.25						
RBH	2	128.454	-	-	-	-	+0.066						
NASA VI A	14	126.586	+0.024	-	+0.034	-	-	+0.018					

TABLE 42. - DIMENSIONAL CHANGES IN SERIES G SPECIMENS

Cycled 2065/675°F (1129/357°C), 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Initial Dimensions, in. Length	Width	Thickness	Radius Nom. 0.040	Radius Nom. 0.025	Cycled	Dimensions After Testing, in. Length	Width	Thickness	Radius Nom. 0.040	Radius Nom. 0.025
B1900 + Jocoat	A	4.012	1.242	0.250	0.042	0.026	1700	Lost during test				
B1900 + Jocoat	B	4.000	1.245	0.252	0.042	0.026	1300	a	1.280	0.260	0.041	0.024
B1900 DID + Jocoat	1	3.995	1.233	0.251	0.040	0.025	2300	a	1.240	0.252	0.037	0.022
IN-100 + Jocoat	P	4.010	1.246	0.251	0.040	0.024	300	a	1.247	0.252	0.034	0.019
IN-100 + Xcoat A	1	4.012	1.249	0.252	0.038	0.023	200	4.015	1.251	0.251	0.032	0.019
IN-100 DS	7	4.019	1.253	0.249	0.035	0.019	2400	3.875	0.940	0.185	0.010	0.005
IN-100 DS + Jocoat	5	4.011	1.256	0.251	0.043	0.025	2200	3.939	1.253	0.262	0.033	0.019
MAR-M 200 + Jocoat	2	4.010	1.243	0.252	0.042	0.021	550	a	1.248	0.255	0.040	0.019
MAR-M 200 DS	3	4.001	1.253	0.249	0.040	0.025	2400	3.969	1.222	0.234	0.026	0.003
Udimet 700 wrought, clad + Xcoat B (SEW)	U3	4.020	1.023	0.261	-	0.030	1300	a	b	0.275	-	0.032
NX-188	1	4.030	1.244	0.240	0.040	0.025	500	4.033	1.243	0.238	0.039	0.023
NX-188 + RT-1A coat	3	4.006	1.247	0.244	0.042	0.025	1100	4.010	1.253	0.246	0.041	0.026
NX-188 DS	1	4.212	1.244	0.252	0.043	0.026	6500	4.195	1.219	0.237	0.035	0.013
NX-188 DS + RT-1A coat	4	4.240	1.247	0.250	0.042	0.024	6100	4.237	1.240	0.261	0.037	0.030
WAZ-20 + Jocoat	3	3.980	1.235	0.258	0.045	0.032	50	3.985	1.236	0.258	0.044	0.031
WAZ-20 DS + Jocoat	3	4.000	1.235	0.260	0.046	0.029	6100	3.994	1.140	0.250	0.022	0.017
TAZ-8A		4.005	1.245	0.247	0.044	0.024	1100	4.005	1.249	0.250	0.045	0.025
TAZ-8A (SEW)		3.970	0.981	0.253	-	0.022	6100	3.964	0.997	0.252	-	0.023
TAZ-8A clad + Xcoat B (SEW)	R4	3.977	1.016	0.252	-	0.028	6100	b	b	0.265	-	0.035
TAZ-8A DS	1	4.245	1.249	0.248	0.040	0.026	2200	4.245	1.245	0.249	0.036	0.020
IN-738	2	4.001	1.246	0.254	0.041	0.026	200	a	1.249	0.255	0.048	0.024
MAR-M 509	9	4.010	1.246	0.248	0.042	0.026	500	3.998	1.256	0.251	0.045	0.026
René 80	1	4.030	1.241	0.251	0.042	0.028	200	4.029	1.242	0.252	0.040	0.025
RBH	1	4.014	1.238	0.246	0.043	0.030	300	4.004	1.248	0.247	0.042	0.029
NASA VI A	2	4.037	1.247	0.250	0.044	0.028	300	4.039	1.247	0.251	0.044	0.024
TD-NiCr		4.017	1.250	0.246	0.041	0.025	200	4.019	1.253	0.252	0.041	0.024
X-40		4.000	1.240	0.246	0.042	0.028	300	3.975	1.251	0.249	0.041	0.026

[a]Ends missing.

[b]Cladding detached.

TABLE 43. - DIMENSIONAL CHANGES IN SERIES H SPECIMENS

Cycled 1915/525°F (1046/274°C), 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Initial Dimensions, in.					Cycled	Dimensions After Testing, in.				
					Radius						Radius	
		Length	Width	Thick-ness	Nom. 0.040	Nom. 0.025		Length	Width	Thick-ness	Nom. 0.040	Nom. 0.025
B1900		4.025	1.243	0.249	0.042	0.026	600	4.021	1.244	0.249	0.041	0.027
IN-100		4.010	1.243	0.251	0.037	0.021	200	4.010	1.245	0.251	0.035	0.019
IN-100 + Jocoat	T	4.013	1.247	0.251	0.032	0.019	500	4.012	1.248	0.252	0.033	0.016
IN-100 + Xcoat A	2	4.011	1.247	0.254	0.038	0.023	500	4.012	1.247	0.254	0.037	0.021
MAR-M 200		4.005	1.244	0.251	0.036	0.018	200	4.008	1.245	0.251	0.036	0.019
Udimet 700 wrought		4.000	1.253	0.251	0.038	0.022	200	4.004	1.255	0.252	0.039	0.023
Udimet 700 cast		4.003	1.243	0.247	0.040	0.025	500	4.004	1.245	0.248	0.038	0.024
TAZ-8A		4.016	1.250	0.246	0.040	0.024	600	4.015	1.250	0.246	0.042	0.025
M22		4.010	1.246	0.243	0.031	0.021	500	4.007	1.247	0.243	0.033	0.018
IN-713C		4.002	1.240	0.248	0.038	0.018	500	4.005	1.242	0.248	0.038	0.018
IN-738	1	4.000	1.247	0.251	0.041	0.026	500	4.000	1.250	0.252	0.042	0.025
IN-162		3.995	1.243	0.244	0.040	0.021	600	3.995	1.244	0.245	0.039	0.022
MAR-M 509	11	4.029	1.247	0.249	0.042	0.026	500	4.020	1.251	0.249	0.044	0.025
René 80	2	4.038	1.243	0.268	0.032	0.028	500	4.039	1.243	0.268	0.047	0.026
NASA VI A	9	4.015	1.248	0.248	0.044	0.028	600	4.016	1.249	0.249	0.043	0.026
TD-NiCr		4.025	1.250	0.249	0.039	0.025	200	4.025	1.253	0.249	0.038	0.025
MAR-M 302		4.005	1.246	0.244	0.039	0.021	500	4.003	1.247	0.242	0.039	0.023
WI-52		4.002	1.249	0.246	0.044	0.024	500	4.000	1.255	0.249	0.037	0.027
X-40		4.000	1.243	0.251	0.042	0.030	500	3.998	1.246	0.251	0.042	0.029

TABLE 44. - DIMENSIONAL CHANGES IN SERIES I SPECIMENS

Cycled 1990/600°F (1088/316°C), 3 min dwell in each bed

Alloy and Condition	Spec. Ident.	Initial Dimensions, in. Length	Width	Thick-ness	Radius Nom. 0.040	Radius Nom. 0.025	Cycled	Dimensions After Testing, in. Length	Width	Thick-ness	Radius Nom. 0.040	Radius Nom. 0.025
B1900 DID + Jocoat	2	4.000	1.231	0.252	0.040	0.025	1250	3.995	1.234	0.252	0.039	0.024
B1900 DID + Jocoat	4	3.995	1.236	0.252	0.040	0.025	1200	3.995	1.237	0.253	0.041	0.028
IN-100 + Xcoat A		4.014	1.247	0.250	0.038	0.023	470	4.015	1.248	0.249	0.031	0.020
MAR-M 200 + Jocoat	1	4.011	1.243	0.252	0.036	0.021	470	4.013	1.244	0.254	0.034	0.018
MAR-M 200 DS	12	4.000	1.253	0.249	0.039	0.024	4000	3.979	1.225	0.238	0.024	0.004
NX-188	2	3.995	1.242	0.240	0.042	0.025	700	3.993	1.241	0.239	0.040	0.024
NX-188	4	4.004	1.242	0.238	0.040	0.023	500	4.002	1.244	0.236	0.039	0.022
NX-188 + RT-1A coat	1	3.998	1.245	0.251	0.042	0.025	700	3.996	1.249	0.251	0.042	0.024
NX-188 + RT-1A coat	2	4.020	1.245	0.248	0.042	0.024	1200	4.020	1.247	0.249	0.041	0.023
NX-188 DS	2	4.306	1.241	0.248	0.043	0.026	6250	4.295	1.220	0.235	0.030	0.010
NX-188 DS	4	4.280	1.242	0.251	0.043	0.026	6250	4.270	1.224	0.239	0.033	0.010
NX-188 DS + RT-1A coat	1	4.275	1.247	0.252	0.043	0.024	6250	4.289	1.253	0.259	0.044	0.027
NX-188 DS + RT-1A coat	2	4.305	1.246	0.254	0.043	0.026	6250	4.312	1.249	0.235	0.042	0.034
WAZ-20 + Jocoat	1	3.977	1.232	0.257	0.045	0.032	700	3.980	1.236	0.258	0.045	0.031
WAZ-20 + Jocoat	2	3.995	1.233	0.259	0.045	0.032	700	4.006	1.234	0.260	0.045	0.030
WAZ-20 DS + Jocoat	1	4.000	1.233	0.260	0.046	0.029	5500	4.062	1.215	0.275	0.020	0.014
WAZ-20 DS + Jocoat	2	4.002	1.230	0.261	0.046	0.029	5500	4.065	1.205	0.270	0.029	0.024
TAZ-8A		4.020	1.249	0.243	0.040	0.024	1200	4.019	1.251	1.244	0.041	0.022
TAZ-8A (SEW)		3.970	0.982	0.253	-	0.022	6250	3.971	1.000	0.254	-	0.021
TAZ-8A DS	2	a	1.249	0.250	0.040	0.026	6250	a	1.220	0.249	0.033	0.013
TAZ-8A DS	4	a	1.249	0.249	0.040	0.026	6250	a	1.223	0.249	0.037	0.012
IN-738	3	4.009	1.246	0.250	0.041	0.026	500	4.010	1.248	0.252	0.044	0.026
MAR-M 509	15	4.028	1.245	0.249	0.042	0.026	700	4.023	1.247	0.251	0.043	0.026
René 80	3	4.010	1.247	0.250	0.042	0.028	500	4.009	1.244	0.251	0.038	0.022
RBH	2	4.008	1.238	0.252	0.043	0.030	500	4.000	1.247	0.251	0.043	0.029
NASA VI A	14	4.011	1.246	0.250	0.044	0.028	700	4.013	1.250	0.251	0.044	0.026

[a]Cannot be accurately measured.

TABLE 45. - SUMMARY OF AVERAGE WEIGHT CHANGE RATES

Alloy and Condition	Weight Change Rate, g/1000 cycles		
	2065/675°F (1129/357°C)	1915/525°F (1046/274°C)	1990/600°F (1088/316°C)
B1900	-	+0.06	-
B1900 + Jocoat	+0.017 (+0.010)	-	-
B1900 DID + Jocoat	-0.073	-	-0.16 (+0.014)
IN-100	-	-1.10	-
IN-100 + Jocoat	-0.40	-0.16	-
IN-100 + Xcoat A	+0.10	-0.30	+0.055
IN-100 DS	-13.20	-	-
IN-100 DS + Jocoat	-2.31	-	-
MAR-M 200	-	+0.25	-
MAR-M 200 + Jocoat	+0.10	-	+0.085
MAR-M 200 DS	-5.94	-	-2.88
Udimet 700 wrought	-	+0.20	-
Udimet 700 cast	-	-0.24	-
Udimet 700 wrought, clad + Xcoat B (SEW)	+0.07	-	-
NX-188	-1.24	-	-1.06 (+0.44)
NX-188 + RT-1A coating	+0.58	-	-0.14 (-0.21)
NX-188 DS	-1.55	-	-1.47 (-1.32)
NX-188 DS + RT-1A coating	-0.37	-	-0.014 (-0.113)
WAZ-20 + Jocoat	+0.24	-	+0.10 (+0.21)
WAZ-20 DS + Jocoat	-3.29	-	-0.90 (-0.90)
TAZ-8A	+0.02	+0.04	-0.019
TAZ-8A (SEW)	-1.10	-	-1.0
TAZ-8A clad + Xcoat B (SEW)	-0.08	-	-
TAZ-8A DS	-0.71	-	-0.61 (-0.56)
M22	-	+0.02	-
IN-713C	-	-0.04	-
IN-738	+0.35	+0.08	+0.07
IN-162	-	+0.02	-
MAR-M 509	+0.05	+0.10	+0.006
René 80	-0.40	-0.56	-0.50
RBH	+0.20	-	+0.13
NASA VI A	+0.35	+0.08	+0.026
TD-NiCr	0	-0.05	-
MAR-M 302	-	-0.06	-
WI-52	-	-0.42	-
X-40	0	-0.02	-

( ) Indicates duplicate specimen.

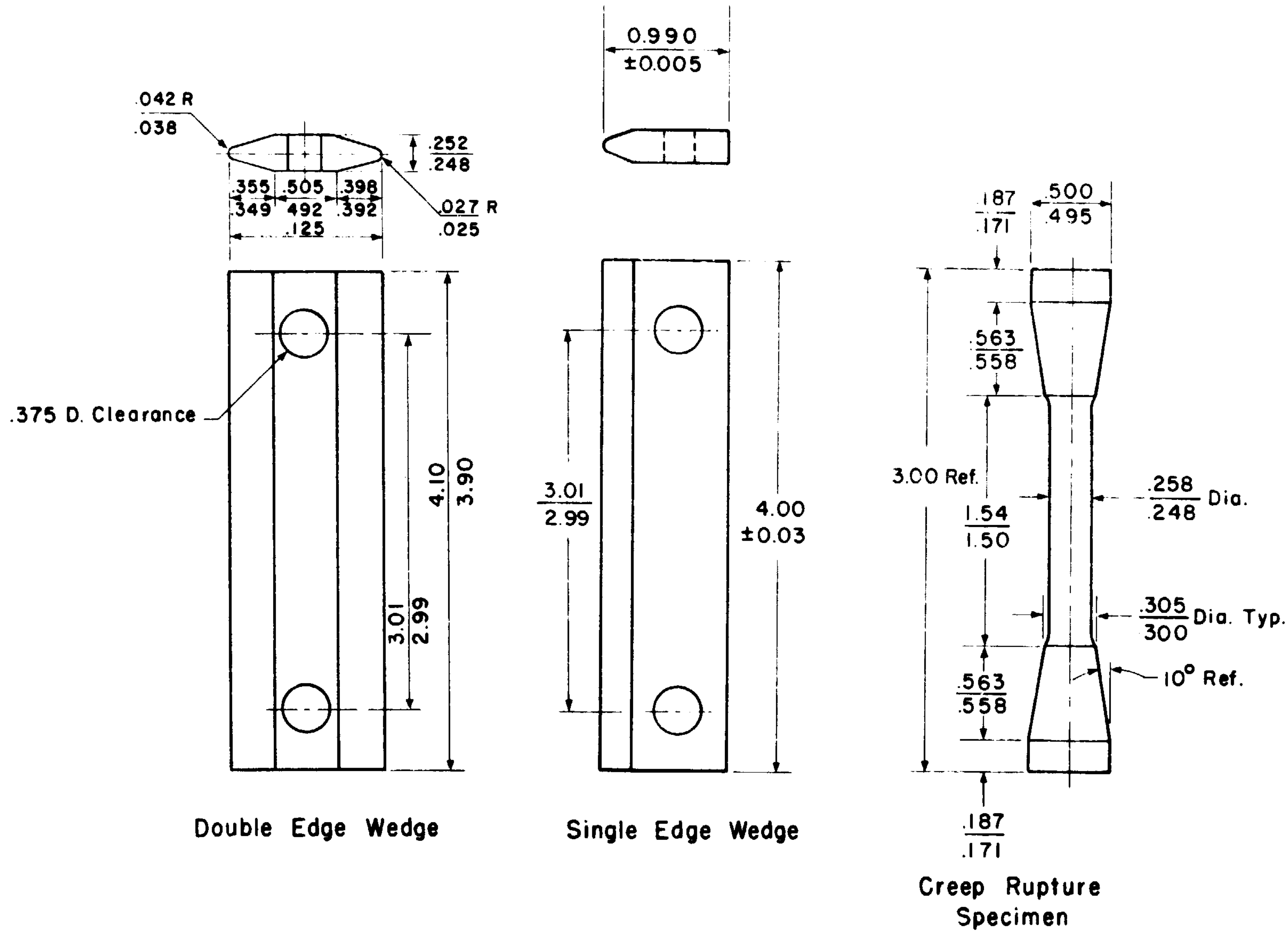


Figure 1

Dimensions of Test Specimens Used in the Program

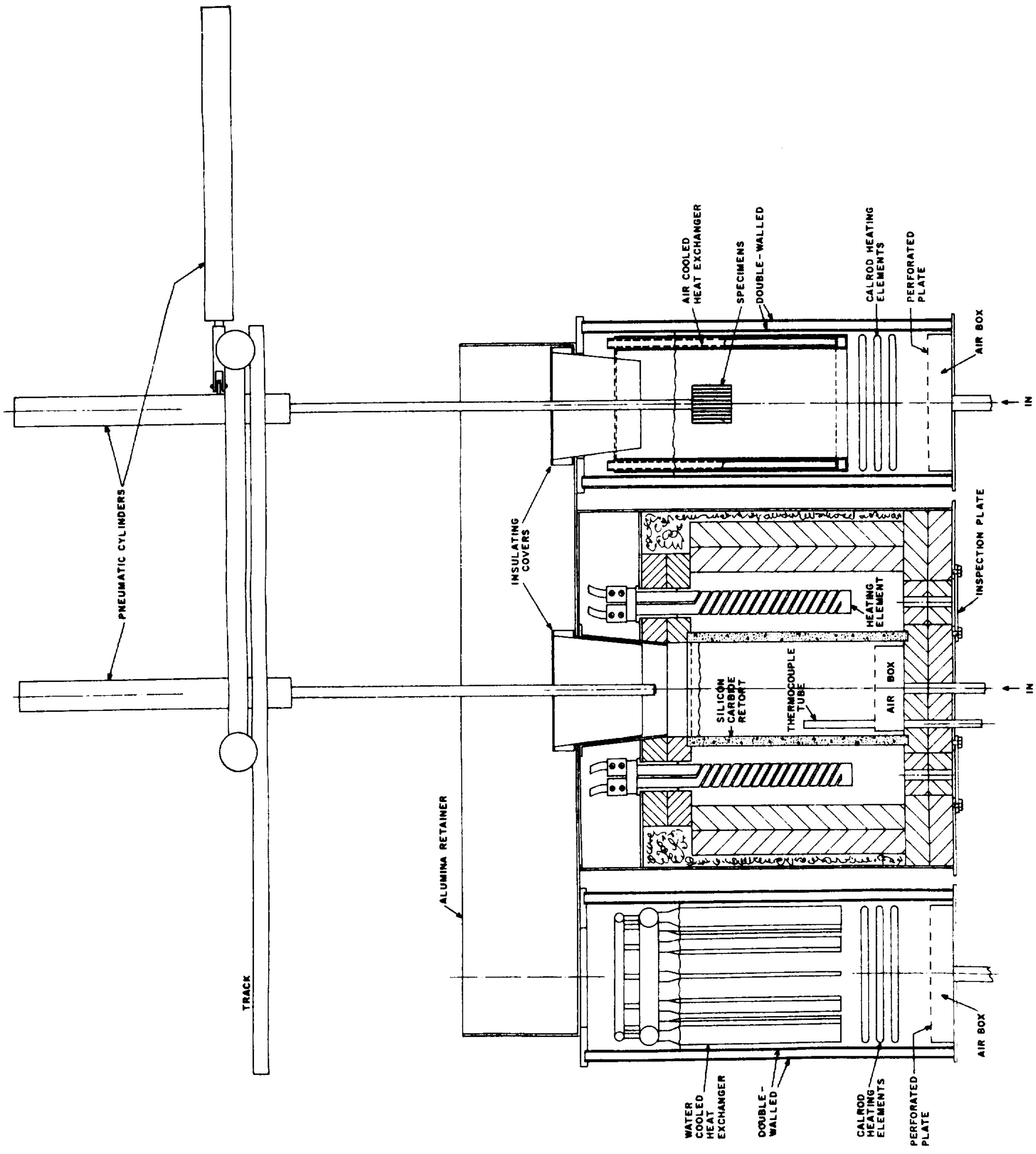


Figure 2

Thermal Fatigue Facility

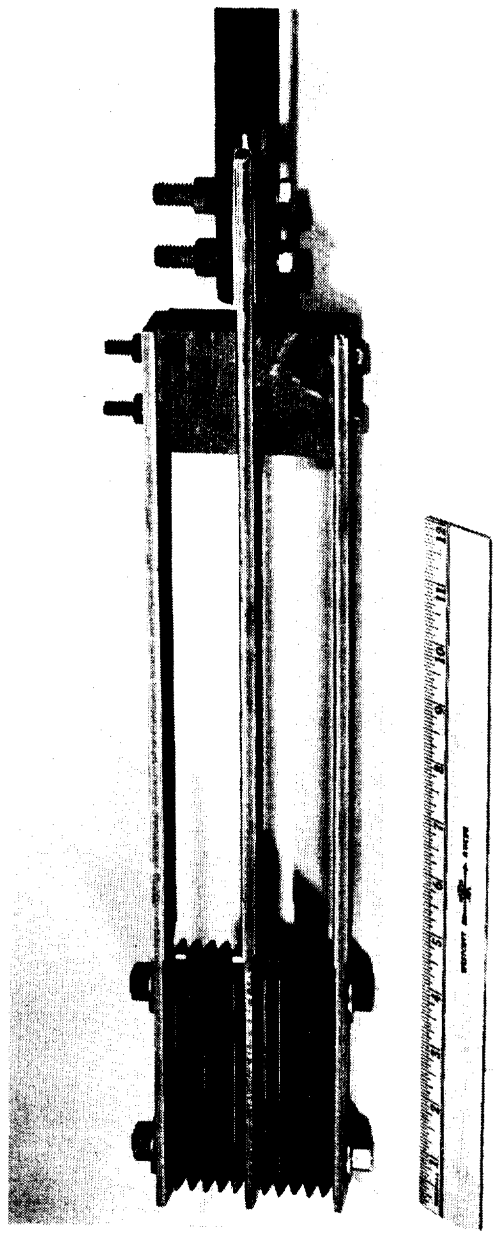
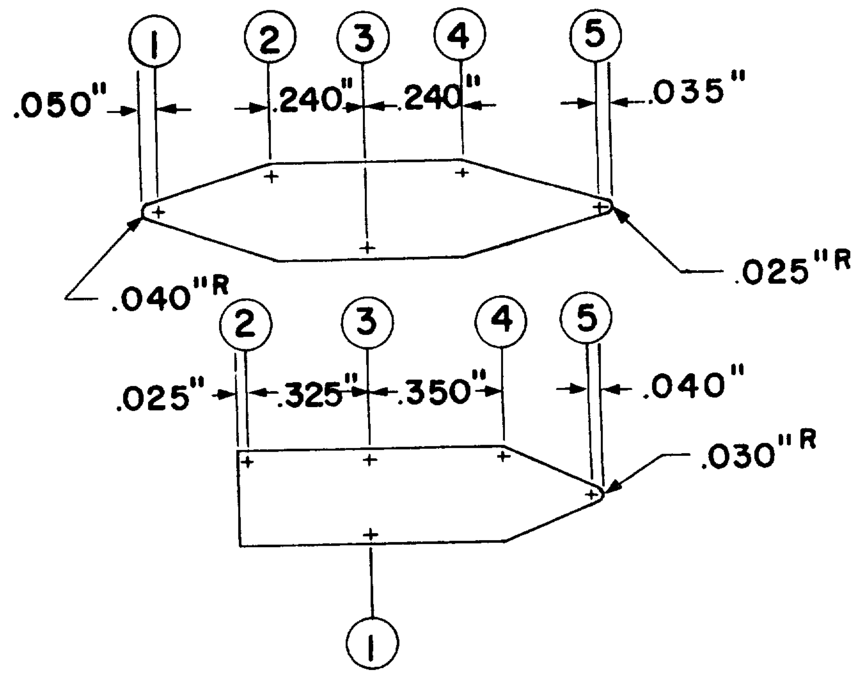


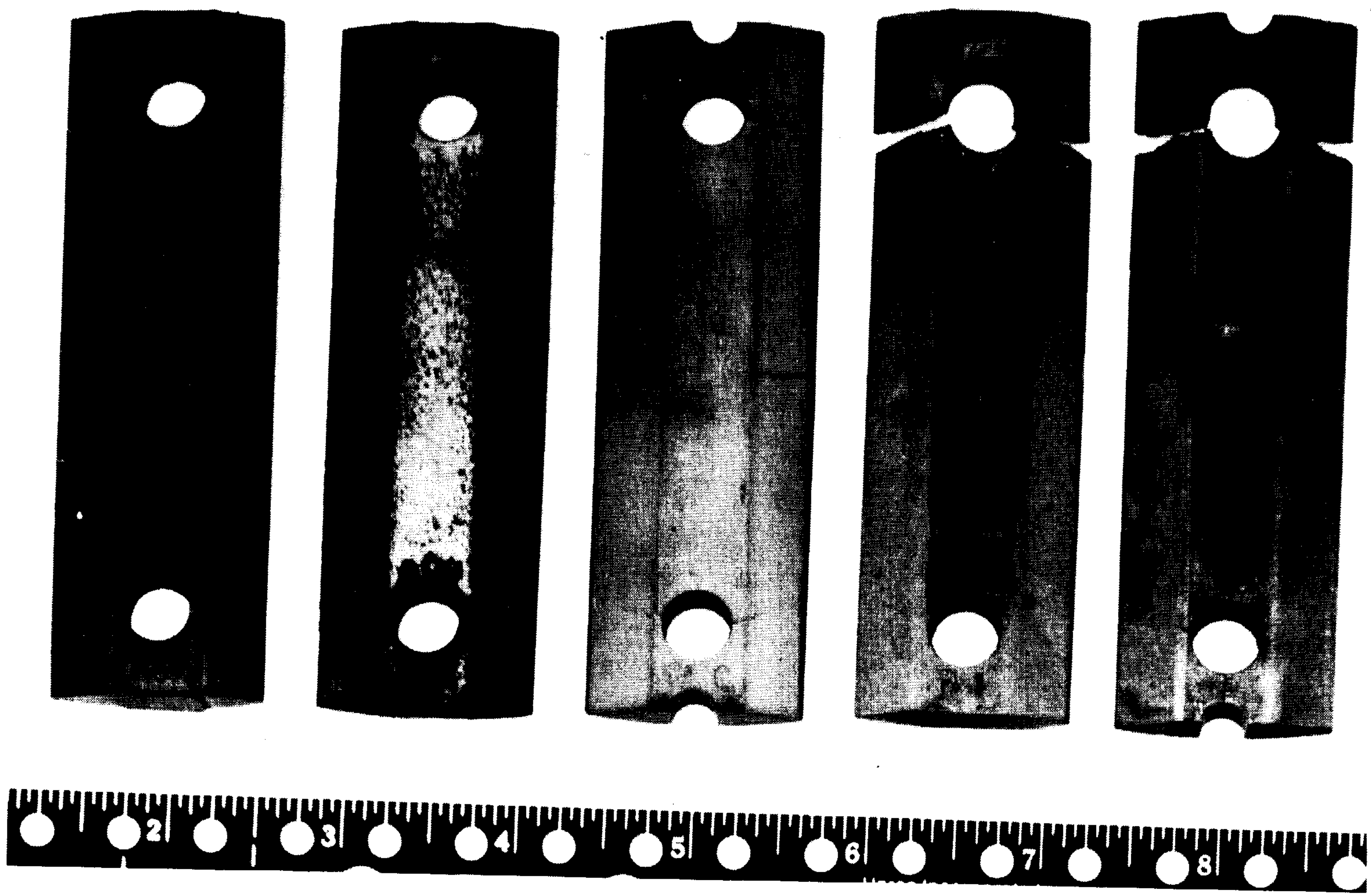
Figure 3
Thermal Fatigue Fixture



ALL THERMOCOUPLES ARE 0.010" BELOW SURFACE AND AT MID-CHORD OF SPECIMEN

Figure 4

Thermocouple Locations in Instrumented Specimens.



NASA VI A (12)
(300 cycles)

MAR-M 509 (9)
(600 cycles)

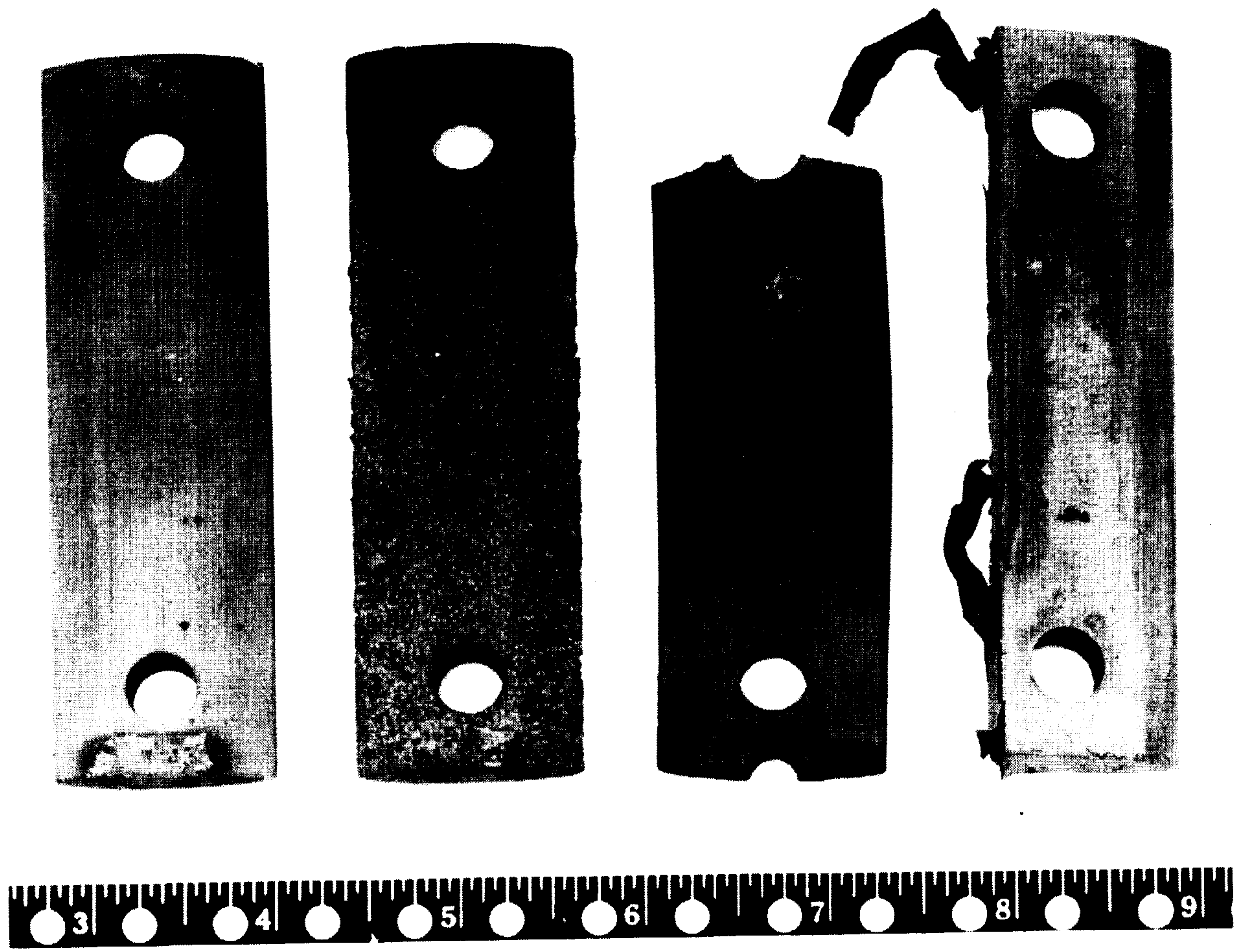
IN-100 +
Xcoat A
(200 cycles)

B1900 DID +
Jocoat (1)[a]
(1300 cycles)

IN-100 +
Jocoat (P)
(300 cycles)

[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

Figure 5
Appearance of Series G Specimens After Indicated Thermal Cycles



WAZ-20 + Jocoat (3) (50 cycles)

WAZ-20 DS + Jocoat (3)[a] (1600 cycles)

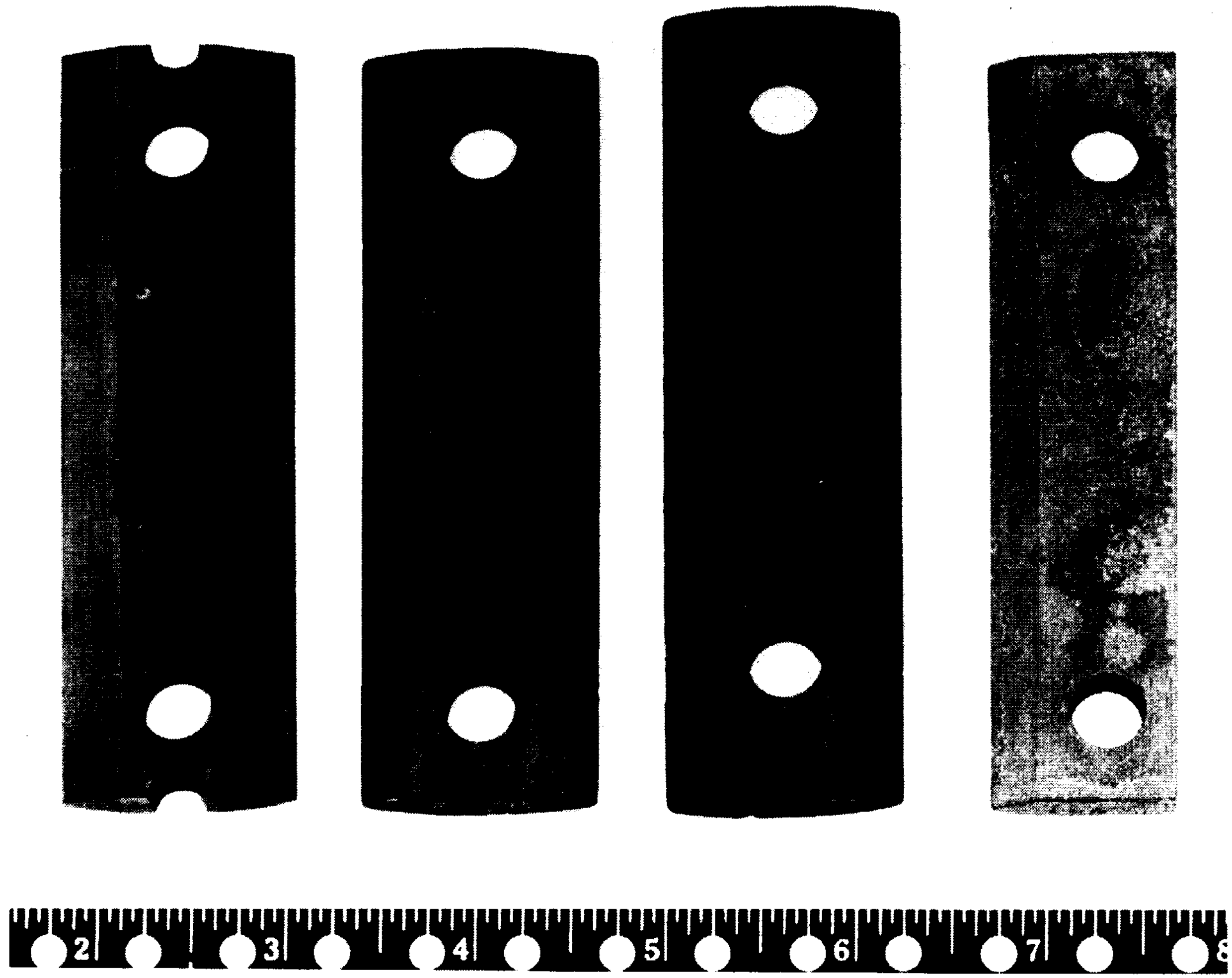
B1900 + Jocoat (A)[a] (700 cycles)

TAZ-8A (SEW) Clad + Xcoat B (R4)[a] (1600 cycles)

[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

(b)

Figure 5 (cont.)

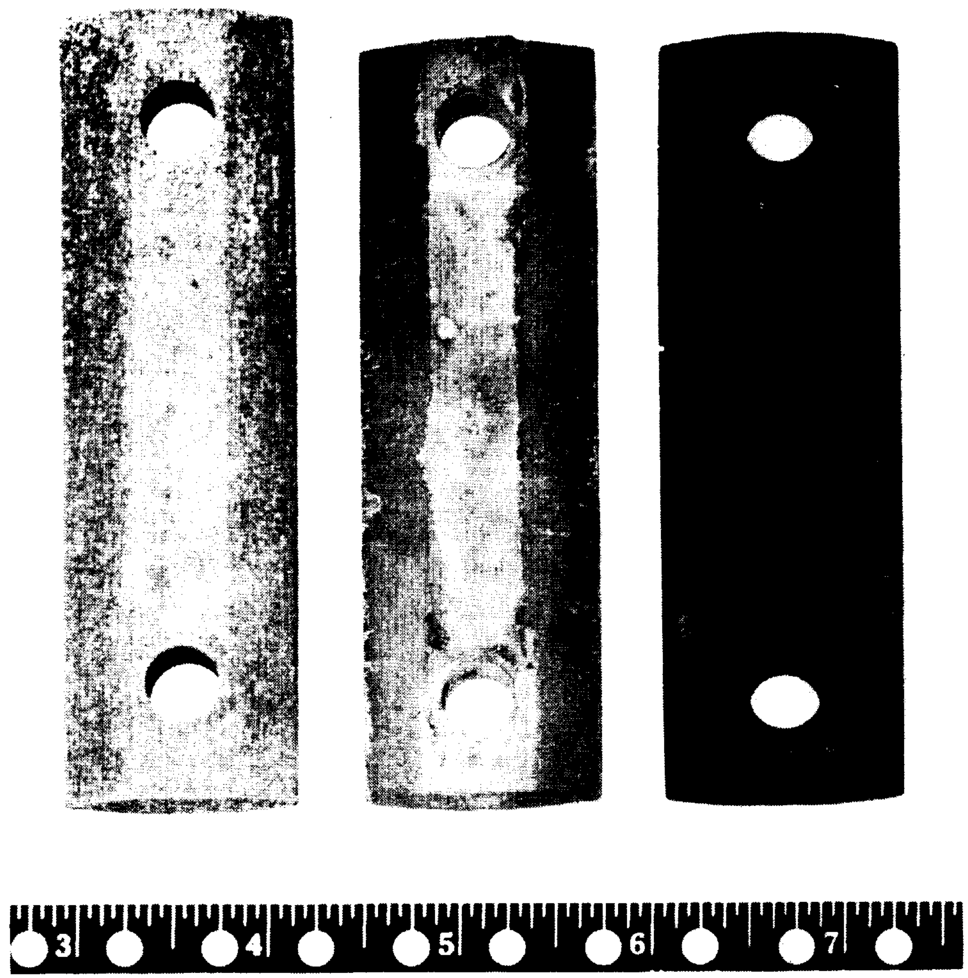


MAR-M 200 + Jocoat (2) (50 cycles)	NX-188 + RT-1A Coating (1100 cycles)	NX-188 DS + RT-1A Coating (4)[a] (1600 cycles)	TAZ-8A (SEW)[a] (1600 cycles)

[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

(c)

Figure 5 (cont.)

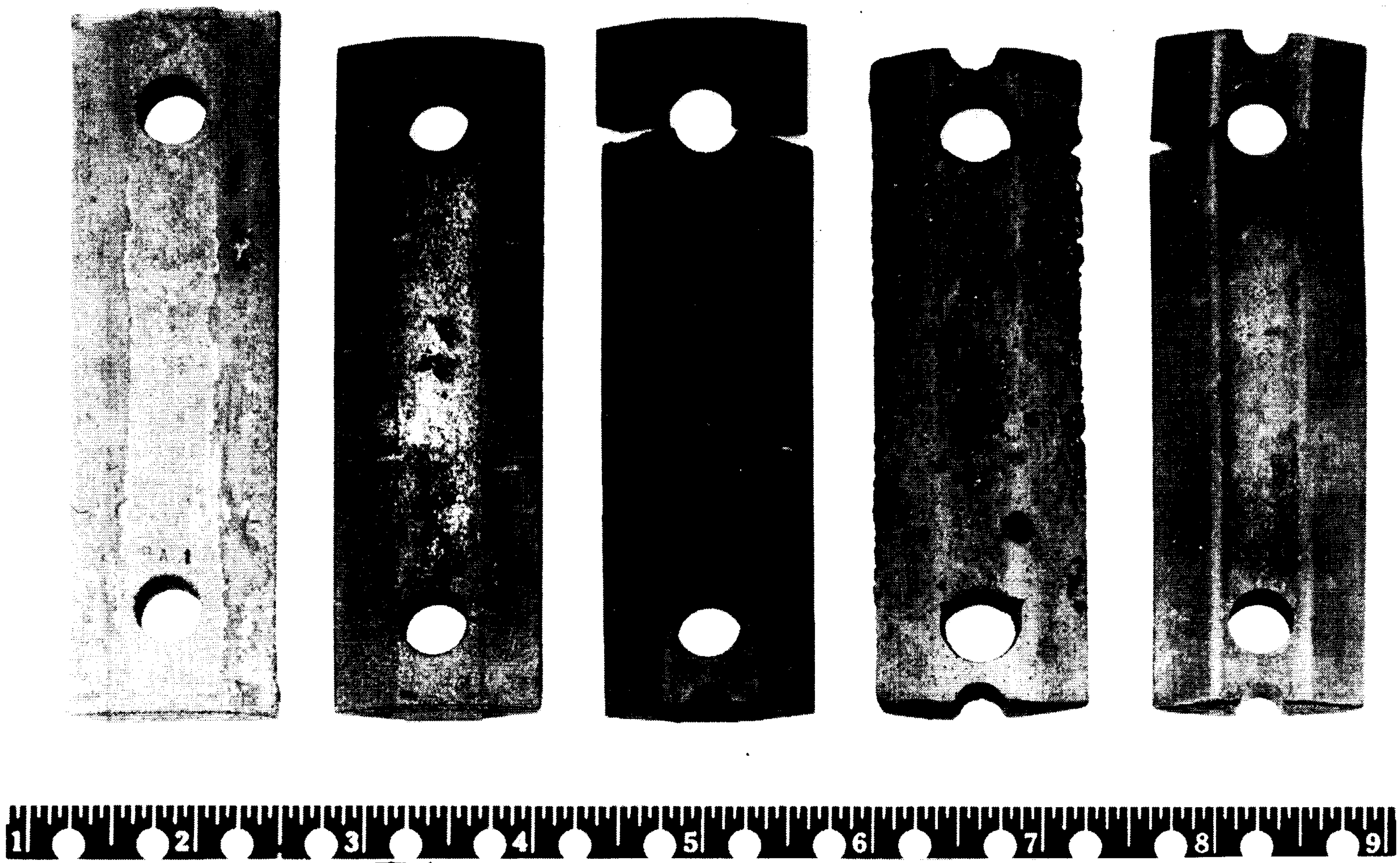


NX-188 DS (1)[a] (2000 cycles) | NX-188 (1) (500 cycles) | RBH (1) (300 cycles)

[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

(d)

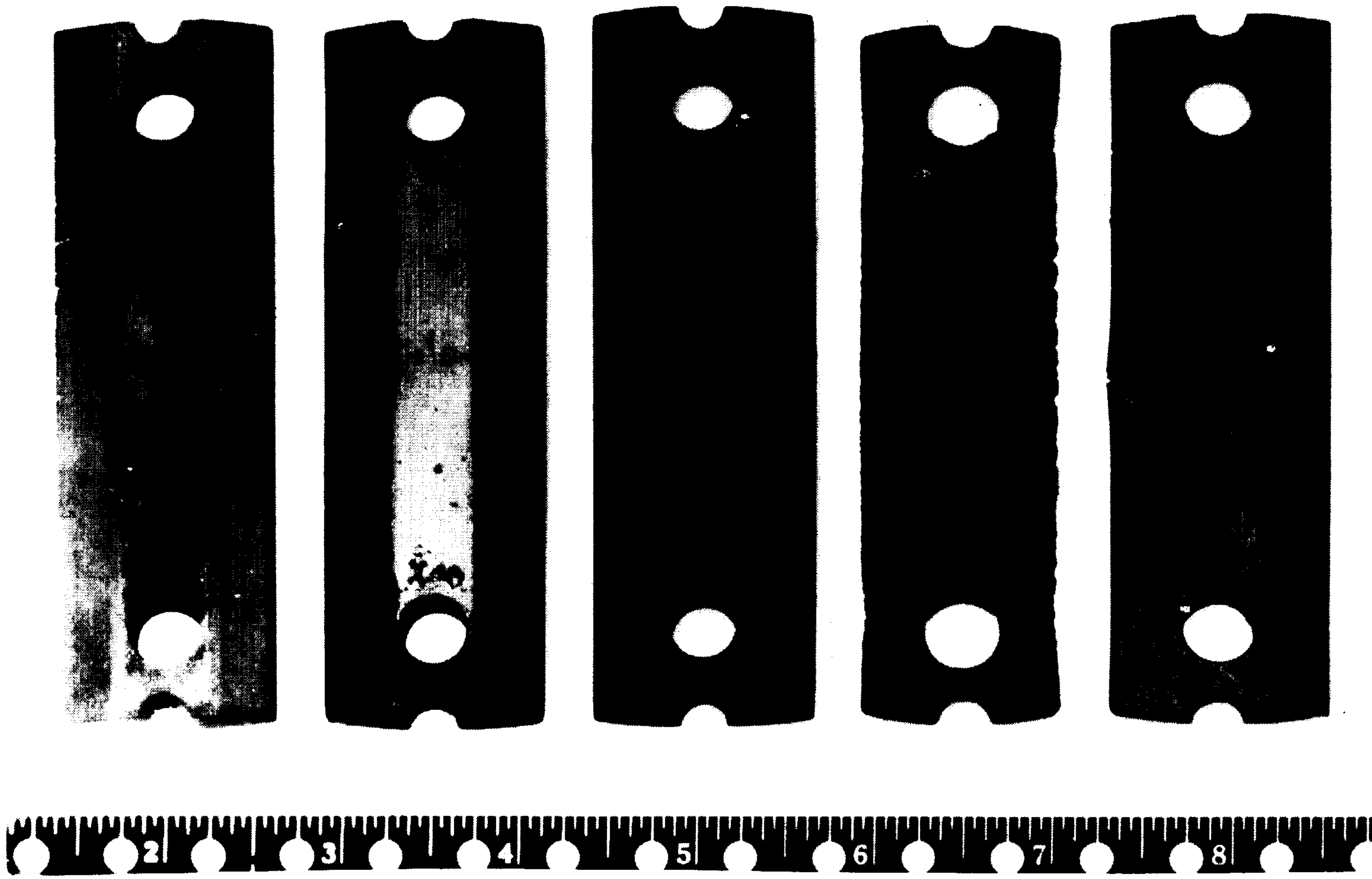
Figure 5 (cont.)



[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

(e)

Figure 5 (cont.)

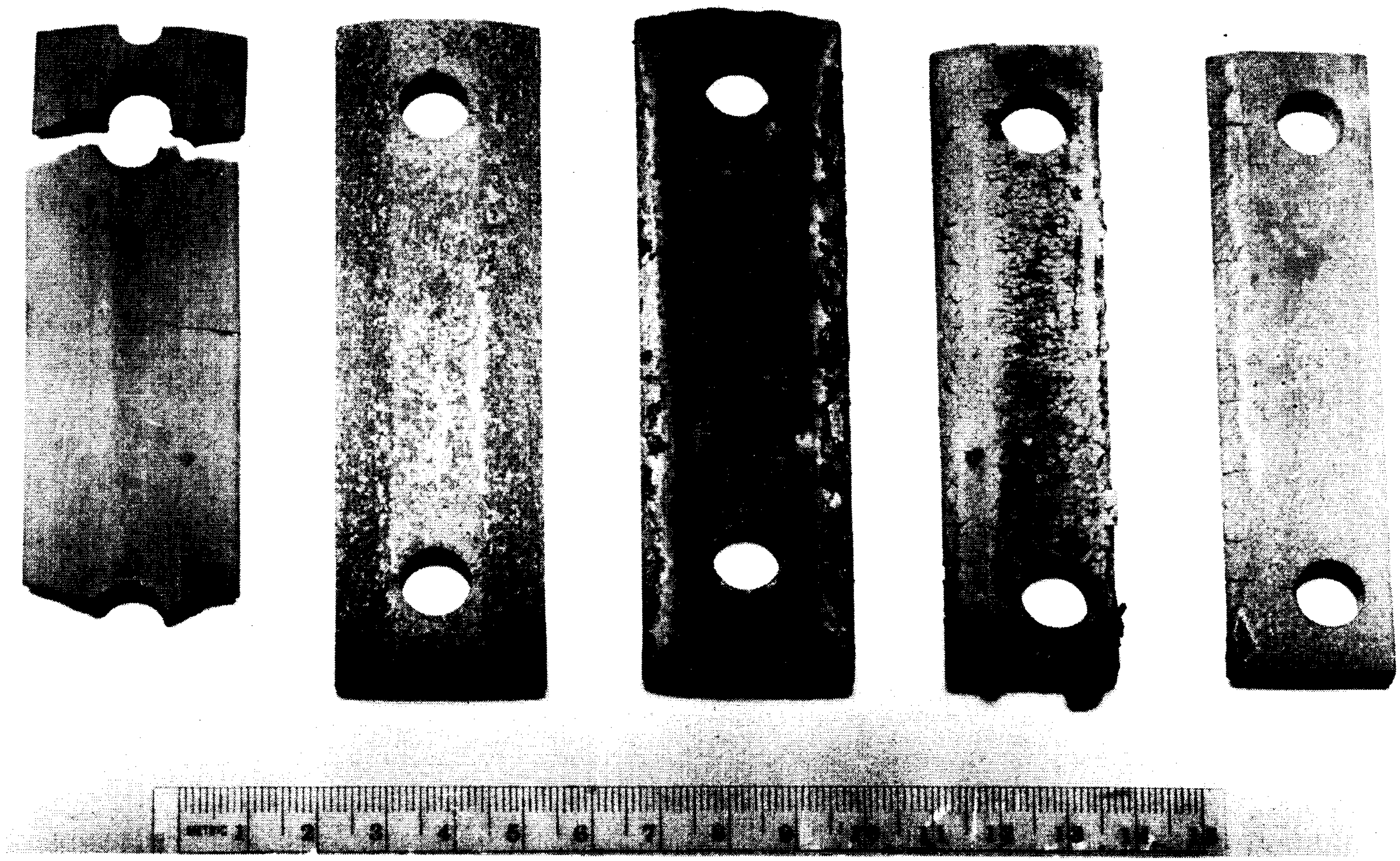


TAZ-8A (1700 cycles) | X-40 (300 cycles) | TD-NiCr (200 cycles) | IN-100 DS (7)[a] (2400 cycles) | MAR-M 200 DS (3) (2400 cycles)

[a]Specimen is shown at a later stage of testing in Fig. 5g or 5h.

(f)

Figure 5 (cont.)

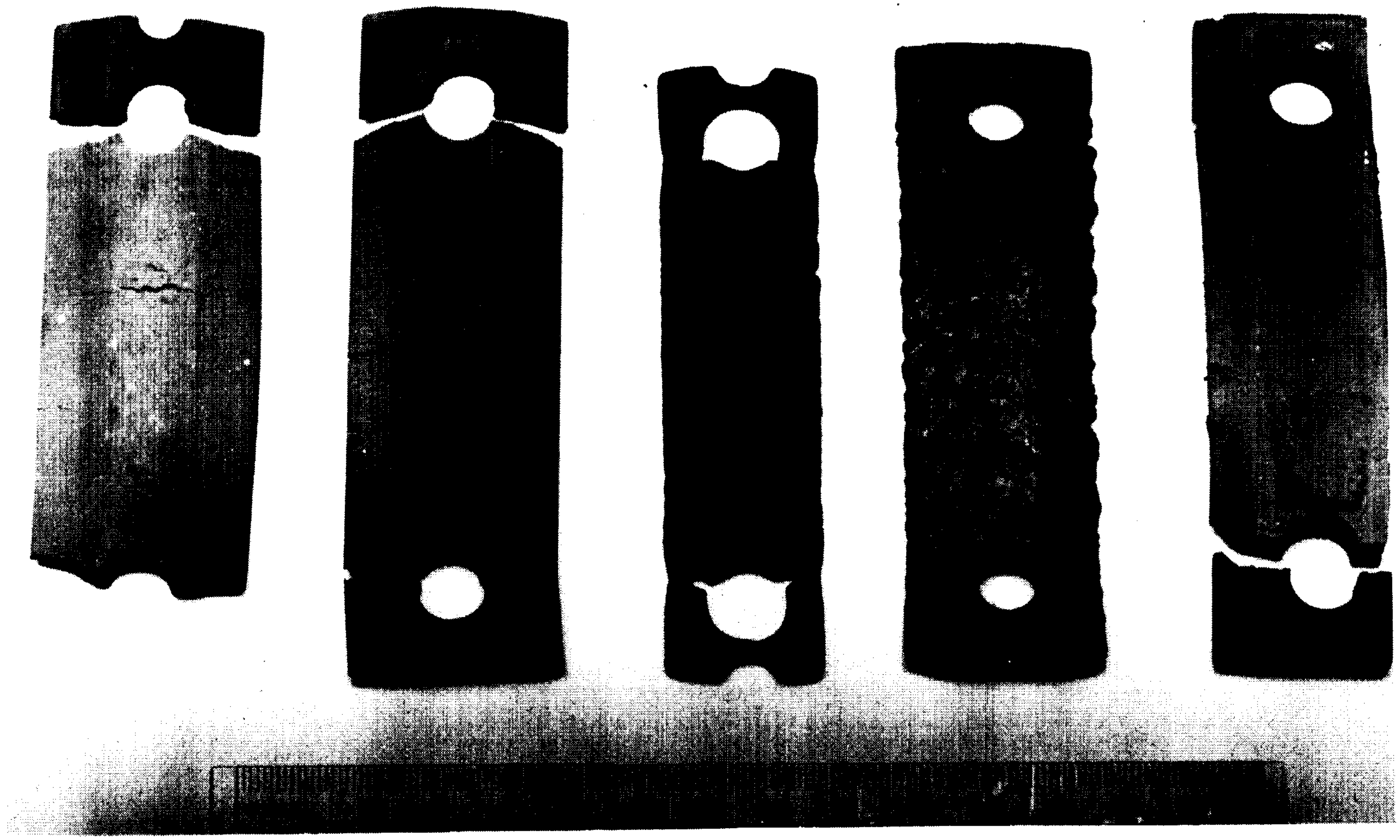


B1900 + Jocoat (A) (1700 cycles)	NX-188 DS (1) (6500 cycles)	NX-188 DS + RT-1A Coating (4) (6100 cycles)	TAZ-8A (SEW) Clad + Xcoat B (R4) (6100 cycles)	TAZ-8A (SEW) (6100 cycles)

(g)

Figure 5 (cont.)

(Note: Specimens shown in Figs. 5g and 5h (except Udimet 700) are shown in an earlier stage of test in Figs. 5a-5f.)



B1900 + Jocoat (B) (1300 cycles)	B1900 DID + Jocoat (1) (2300 cycles)	IN 100-DS (7) (2900 cycles)	WAZ-20 DS + Jocoat (3) (6100 cycles)	Udimet 700 Wrought Clad + Xcoat B (U3) (1300 cycles)

(h)

Figure 5 (cont.)

(Note: Specimens shown in Figs. 5g and 5h (except Udimet 700) are shown in an earlier stage of test in Figs. 5a-5f.)

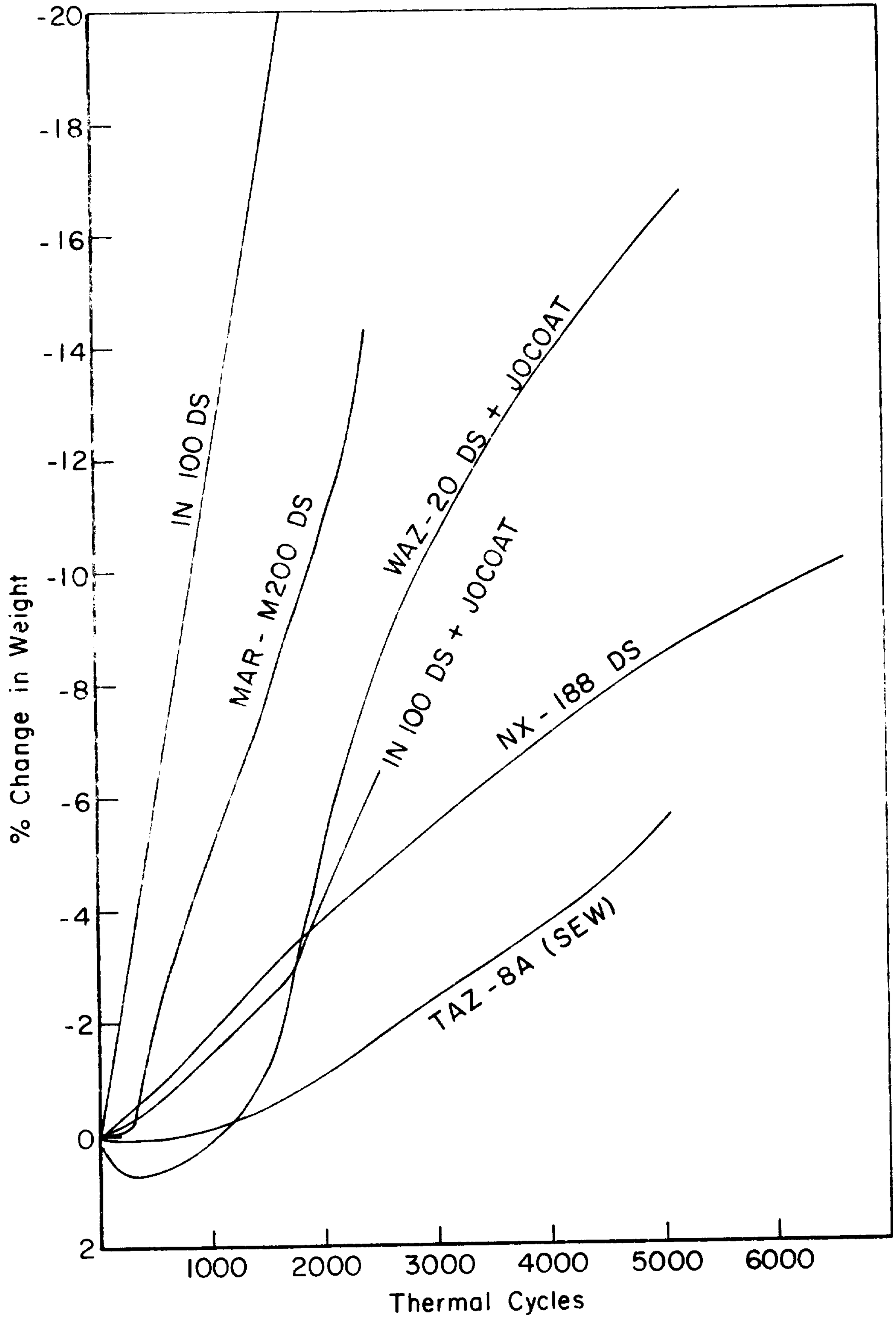


Figure 6

Weight Changes of Some Series G Specimens